Work Plan

for

Groundwater Monitoring
Former Melville North Landfill

Naval Station Newport
Newport, Rhode Island

Environmental Field Activity Northeast
Naval Facilities Engineering Command

Contract Number N62467-94-D-0888
Contract Task Order 0842

May 2003

TETRA TECH NUS, INC.

W5203283F

WORK PLAN

FOR

GROUNDWATER MONITORING
FORMER MELVILLE NORTH LANDFILL

NAVAL STATION NEWPORT
NEWPORT, RHODE ISLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Environmental Field Activity Northeast
Environmental Branch (Code EV2)
Naval Facilities Engineering Command
10 Industrial Highway, Mail Stop #82
Lester, Pennsylvania 19113-2090

Submitted by:
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CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0842

May 2003

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1.0 INTRODUCTION

This Work Plan has been prepared under the Comprehensive Long -Term Environmental Action Navy (CLEAN) Contract No. N62472-94-D-0888, Contract Task Order (CTO) 842. The statement of work requires Tetra Tech NUS, Inc. (TtNUS) to install monitoring wells and perform two rounds of groundwater monitoring at the Former Melville North Landfill (the Site), Portsmouth, Rhode Island. This Work Plan describes the procedures for performance of this effort.

1.1 OBJECTIVE

The objective of the groundwater monitoring effort is to evaluate groundwater quality at the Site following the soil cleanup completed in 2000.

The Melville North Landfill Site is located in the Melville North area of Portsmouth along the shoreline of Narragansett Bay (Figure 1-1). The site is situated in a low-lying wetland area between Defense Highway and Narragansett Bay.

1.2 WORK PLAN FORMAT

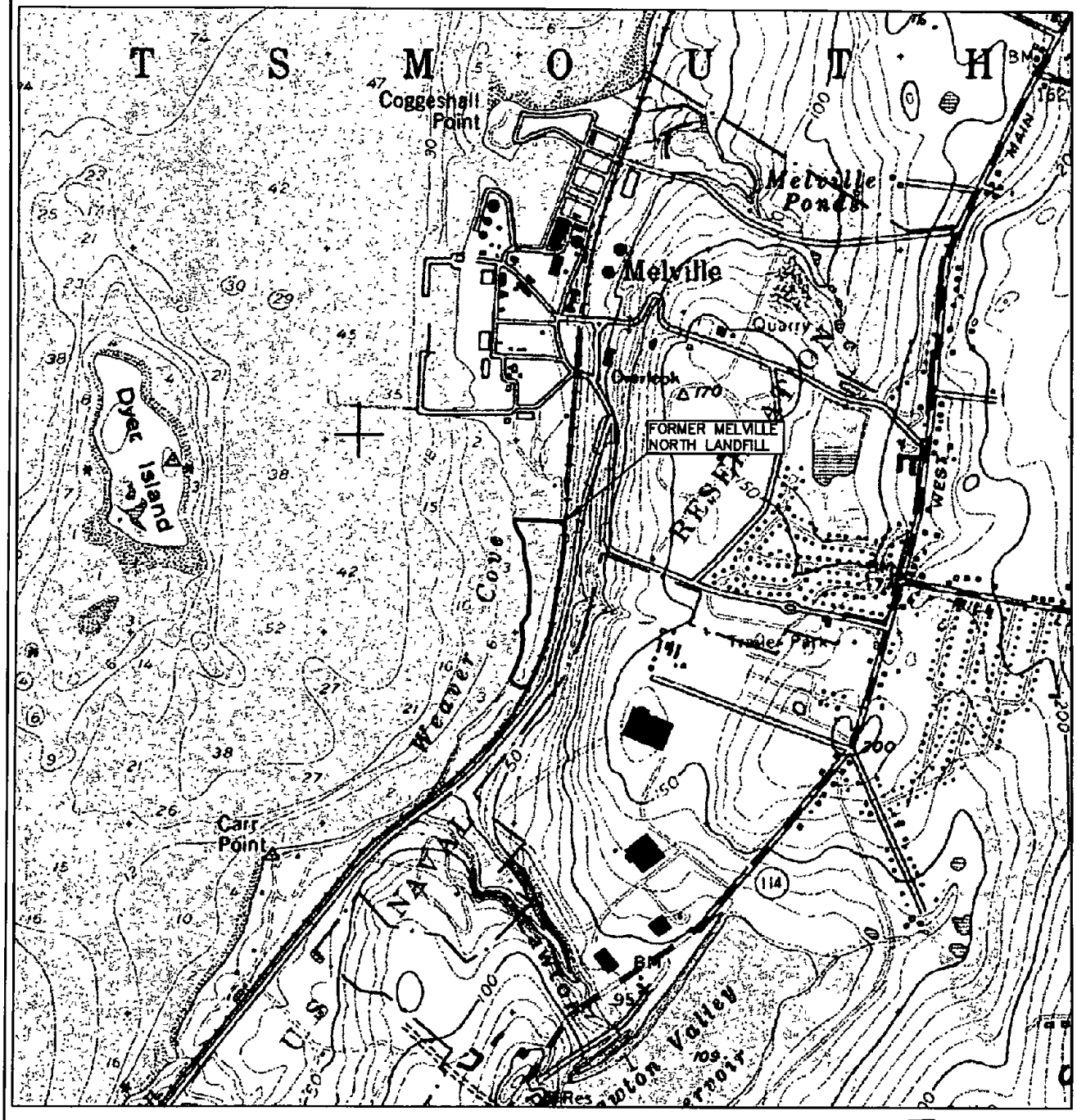
The basic format of this Work Plan reflects that of similar documents provided for regulatory approval under the CLEAN contract for the Newport Installation Restoration Program sites.

Section 1.0 of this Work Plan describes the project organization and communication pathways, personnel responsibilities, and a process for revision to the Work Plan during field activities.

Section 2.0 of this Work Plan presents the project planning and project definitions. Within this section, site history, site location and description is presented.

Section 3.0 presents a description of the data collection activities planned for this groundwater investigation. This includes a rationale for placement of wells, description of well installation efforts, and sampling and data acquisition procedures and analysis requirements.

Section 4.0 presents the Quality Assurance (QA) procedures to be utilized for this groundwater investigation. This section includes the project quality objectives, project action limits, and measurement performance criteria.



BASE MAP IS A PORTION OF THE FOLLOWING 7.5 X 15 MINUTE U.S.G.S. QUADRANGLE:
PRUDENCE ISLAND, RHODE ISLAND, 1955, PHOTOREVISED 1970 AND 1975

GRAPHIC SCALE
0 0.5 MILE 1 MILE

QUADRANGLE LOCATION

SITE LOCUS		FIGURE 1-1	
FORMER MELVILLE NORTH LANDFILL			
PORTSMOUTH, RHODE ISLAND			
DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	S. PARKER	DATE:	MARCH 6, 2003
SCALE:	AS NOTED	ACAD NAME:	DWG\5152\0481\FIG_1-1.DWG

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Section 5.0 presents a general outline of the groundwater monitoring reports that will be generated following completion of each field effort. Section 5.0 also provides a tentative schedule for completion of work.

A Site Specific Health and Safety Plan (bound separately) will be used to provide procedures for safe work procedures at the Site to be conducted under this work plan.

1.3 PROJECT ORGANIZATION AND RESPONSIBILITIES

TtNUS will be responsible for the overall management of the project, including the performance of field activities presented in this Work Plan.

Navy personnel from the Environmental Field Activity Northeast (EFANE) will be responsible for administrative and technical oversight of the program, and project management and coordination between state and federal regulatory agencies, while the Navy personnel from the Naval Station Newport (NSN) will be responsible for on-site coordination with TtNUS.

Key Navy personnel supporting this project are as follows:

Todd Bober, Technical Point of Contact
EFANE, Philadelphia, PA Phone: 610-595-0567 FAX: 610-595-0555

Dave Derocz, Facility Contact, NSN PWD – Environment
Building 1, NSN, Newport, R Phone: 401-841-6375 FAX: 401-841-7071

Key TtNUS personnel supporting this project are as follows:

Stephen Parker, Project Manager
TtNUS, Wilmington, MA Phone: (978) 658-7899 FAX: (978) 658-7870

Kayleen Jalkut, Field Operations Leader
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Kelly Johnson-Carper, Lead Chemist, Program Quality Assurance Manager
TtNUS, Pittsburgh, PA Phone: (412) 921-7090 FAX: (412) 921-4040

Matt Soltis, CLEAN Health and Safety Manager
TtNUS, Pittsburgh, PA Phone: (412) 921-7090 FAX: (412) 921-4040

The TtNUS Project Manager (PM) will have the primary responsibility for implementing and managing the investigation. The TtNUS PM will also be responsible for notifying regulatory agencies of field activities or schedule modifications.

The Field Operations Leader (FOL) will be responsible for directing on-site field activities and will report directly to the PM The FOL will coordinate efforts of the field sampling staff, the subcontractors, and the lead technical staff. The FOL will be responsible for identifying problem areas and bringing them to the attention of the PM for resolution.

The Lead Chemist will advise the PM on technical requirements of the chemical data, prepare laboratory specifications for analysis of samples collected, oversee the subcontracted analytical laboratories, and review or oversee the validation of the analytical reports prepared.

The CLEAN Health and Safety Manager is responsible for reviewing health and safety plans for all CLEAN operations, and performs site audits to ensure compliance with program and site health and safety requirements.

The Quality Assurance Manager is responsible for QA/QC requirements for the TtNUS CLEAN program. This individual reviews data and deliverable documents, and performs system audits to ensure contract QA/QC goals are met.

1.4 CHANGES TO THE WORK PLAN

Work Plan development is performed in steps, with the Navy providing draft and final versions to oversight parties to allow for comments and other input. However, during the project execution, it may become necessary to modify the Work Plan after it is finalized. If the plan for collecting data needs to be altered, the Work Plan may be amended through the use of a Request for Field Modification (RFM) form. This form will be prepared by the TtNUS FOL and forwarded to the TtNUS PM. The PM will make a recommendation to the Navy RPM, who will forward the RFM to NSN representatives, the landowner, and to the regulatory oversight RPM. Time limits on acceptance of, or comment to, the field modification requests will be stated.

When changes require immediate action, the proposed change will be implemented at the discretion of the TtNUS project manager in order to avoid schedule delays, cost impacts, and/or subcontractor

standby times. The Navy, landowner, and RIDEM will be notified through delivery of the RFM as described above.

An example of the RFM form is presented in Appendix A.

1.5 SCHEDULE AND REGULATORY OVERSIGHT

A tentative schedule for field investigations is included in Section 5.0. This schedule will be updated as necessary to inform oversight personnel when different tasks and activities are scheduled to occur. A 24-hour advance notification of changes in scheduled field activities will be given to the landowner and RIDEM.

2.0 BACKGROUND INFORMATION

This section presents the project planning effort and project definitions. Within this section, the site location and description and site history are presented.

2.1 SITE LOCATION AND DESCRIPTION

NAVSTA Newport is located in the City of Newport, and Towns of Middletown and Portsmouth, Rhode Island on the western shore of Aquidneck Island facing the east passage of Narragansett Bay (Figure 1-1). The Melville North Landfill site is located in the northwest portion of NAVSTA Newport on the shoreline of Narragansett Bay in the Town of Portsmouth. The site is approximately 10 acres in size and was used as a landfill from World War II until 1955. The site was excessed to the State of Rhode Island in September 1993, and was sold to Melville Marine Industries six months later.

Access to the Melville North Landfill site is gained from the east via Defense Highway. The site is bounded to the west by Narragansett Bay, to the east by the Penn Central railroad tracks and Defense Highway (also known as Burma Rd.), to the north by vegetated wetlands, and to the south by a wooded upland area. The topography of the site is relatively flat with elevation drops between 5 and 10 feet along the shoreline and an increase in elevation between 5 and 10 feet along Defense Highway.

The landfill reportedly received a variety of waste materials from World War II until 1955. These wastes include spent acids, various waste oils, solvents, waste paints, and possibly polychlorinated biphenyls (PCBs). Initial inspections of the site also revealed mounds of oil-soaked soil and surface areas that were covered with oil and oil sludge. It was reported that the mounds of oil-soaked soil came from disposal of the oil sludge material generated while cleaning fuel supply tanks at the nearby tank farms, or from cleanup operations of various oil spills.

2.2 SITE HISTORY

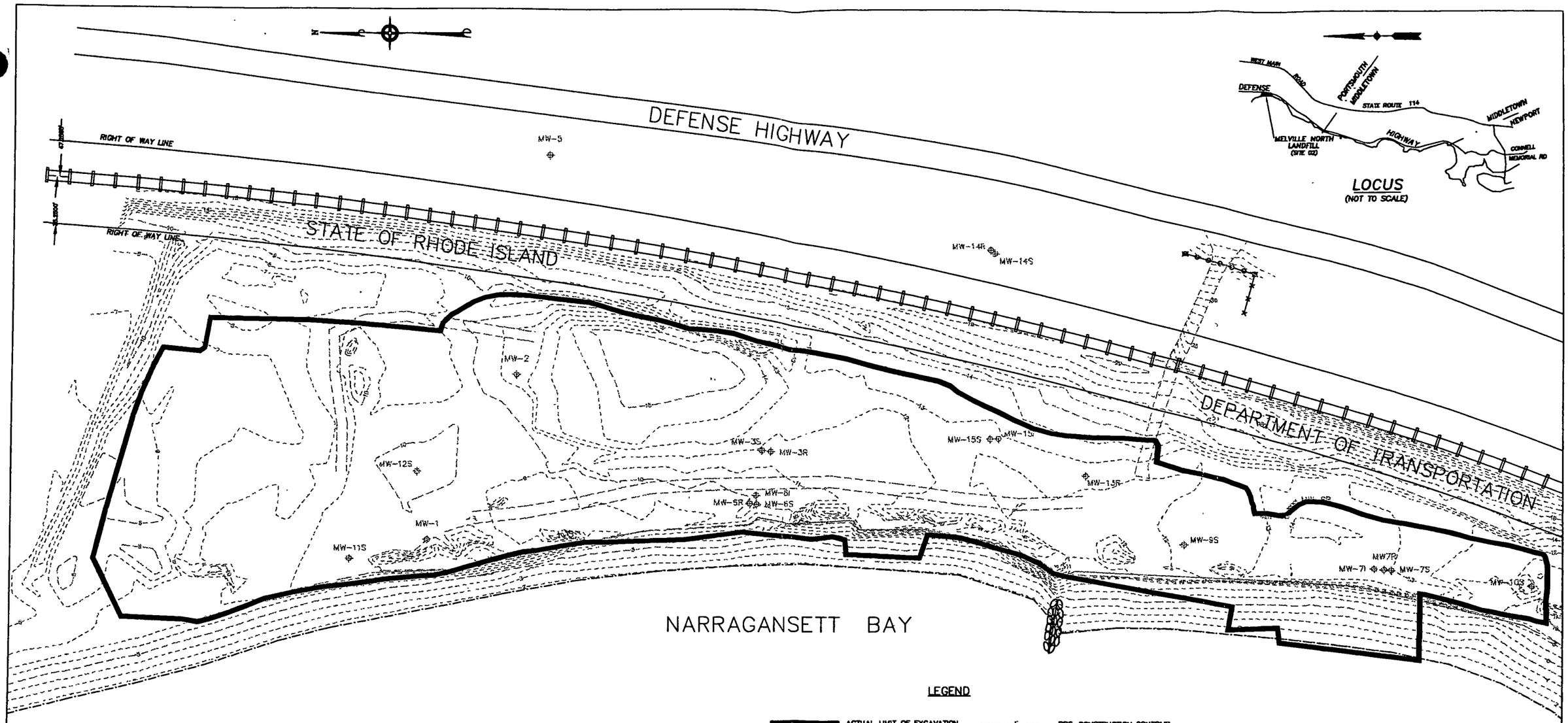
The approximate 10-acre site was used as a landfill for at least the period following World War II until 1955. The date the site first began as a landfill is unclear, but indications are that use began after the war. Following its closure in 1954, wastes generated at the naval complex were disposed of at the McAllister Point Landfill.

The Melville North Landfill received wastes similar to those disposed of in McAllister Point Landfill, including spent acids, waste paints, solvents, waste oils (diesel, fuel, lube), and PCBs. The waste quantity disposed of in the landfill is unknown. During visual inspection of the site, areas covered with oil

and oil sludge were found to be scattered throughout the site. Mounds of oil-soaked soil appeared to have been trucked to and deposited of at the Site. These oil-contaminated mounds could have been the oil sludge materials obtained from the tank farms during tank cleaning operations, or the result of cleanup operations following oil spills.

A series of removal actions have been conducted at the site. The first was performed in 1993 to remove soil piles found to contain oil. These soils were removed from the Site and disposed of at a licensed facility. The second removal action was conducted in 1996 to address additional soils with oil contamination and elevated concentrations of metals. Following the second removal action, a Site Investigation was conducted under RIDEM remediation regulations to, in part, determine a final remedy for the Site.

A third removal action was carried out as a final remedy for the Site by Foster Wheeler Environmental Corporation (FWENC) at the Site from April 15, 1999 to May 3, 2000. Soil excavation was conducted within the excavation area identified on Figure 2-1. The limit of the excavation area was initially mapped out by FWENC based on sample locations that exceeded the RIDEM RDEC and the RIDEM GB Leachability Criteria as determined in the Site Investigation conducted by TtNUS. Field screening, laboratory confirmation sampling, visual inspection, and the presence of large quantities of debris were used during the soil excavation activities to delineate the vertical and horizontal limits of the excavation area. A total of 73,001 cubic yards of soil and debris was removed by the beginning of 2000. An additional 4000 tons of material was excavated from the southern part of the landfill, and this effort was conducted in April 2000.



LEGEND

- ACTUAL LIMIT OF EXCAVATION
- APPROXIMATE LOW WATER
- STONE JETTY
- CHAIN LINK FENCE
- POST & WIRE FENCE
- PRE-CONSTRUCTION CONTOUR
- PRE-CONSTRUCTION ACCESS ROAD
- PRE-CONSTRUCTION APPROXIMATE TOP OF BERM
- MW-3R MONITORING WELL

GRAPHIC SCALE

0' 100' 200'

1 INCH = 100 FEET

REFERENCE PLANS:

1. NAVAL COMPLEX, NEWPORT, R.I., MELVILLE (NORTH), EXISTING CONDITIONS MAP, BY NAVAL FACILITIES ENGINEERING COMMAND, DWG. NO. 994, 207.
2. PLAT SHOWING LAND IN CITY OF NEWPORT & TOWNS OF MIDDLETOWN & PORTSMOUTH, ACQUIRED FOR RAILROAD PURPOSES ON BEHALF OF THE STATE OF RHODE ISLAND & PROVIDENCE PLANTATIONS, BY THE DIRECTOR OF TRANSPORTATION, RAILROAD PLAT NO. 1.
3. BASE PLAN ENTITLED "SITE 02, MELVILLE NORTH LANDFILL, SITE MAP" PREPARED FOR NAVAL EDUCATION TRAINING CENTER, NEWPORT, RHODE ISLAND, SCALE: 1"=60', DWG.NO. 2, PROJ.NO. 6760-N81, DATED: 5/29/91, PREPARED BY: SAI SURVEYING, CO.

NOTES:

1. ALL COORDINATES SHOWN HEREON ARE RHODE ISLAND GRID COORDINATES, NORTH AMERICAN DATUM OF 1927, PER REFERENCE PLAN.
2. ELEVATION DATUM: MEAN LOW WATER, U.S. NAVY.
3. THE CONTOUR INTERVAL IS ONE (1) FEET.
4. CONTROL POINTS 1 & 2 ARE LOCATED ALONG RAILROAD BASELINE, EACH FOUND APPROXIMATELY 1 FOOT BELOW SURFACE.

EXCAVATION AREA			
FORMER MELVILLE NORTH LANDFILL			
PORTSMOUTH, RHODE ISLAND			
DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	S. PARKER	DATE:	MARCH 13, 2003
SCALE:	AS NOTED	FILE NO.:	DWG\5152\0481\FIG_2-1.DWG

FIGURE 2-1

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3.0 SAMPLING AND ANALYSIS PLAN

This section presents a description of the data collection activities planned for this investigation. This Section includes a rationale for field investigation design, description of field investigation efforts, sampling and data acquisition procedures and requirements, and the analytical plan for the samples to be collected.

3.1 WELL INSTALLATION

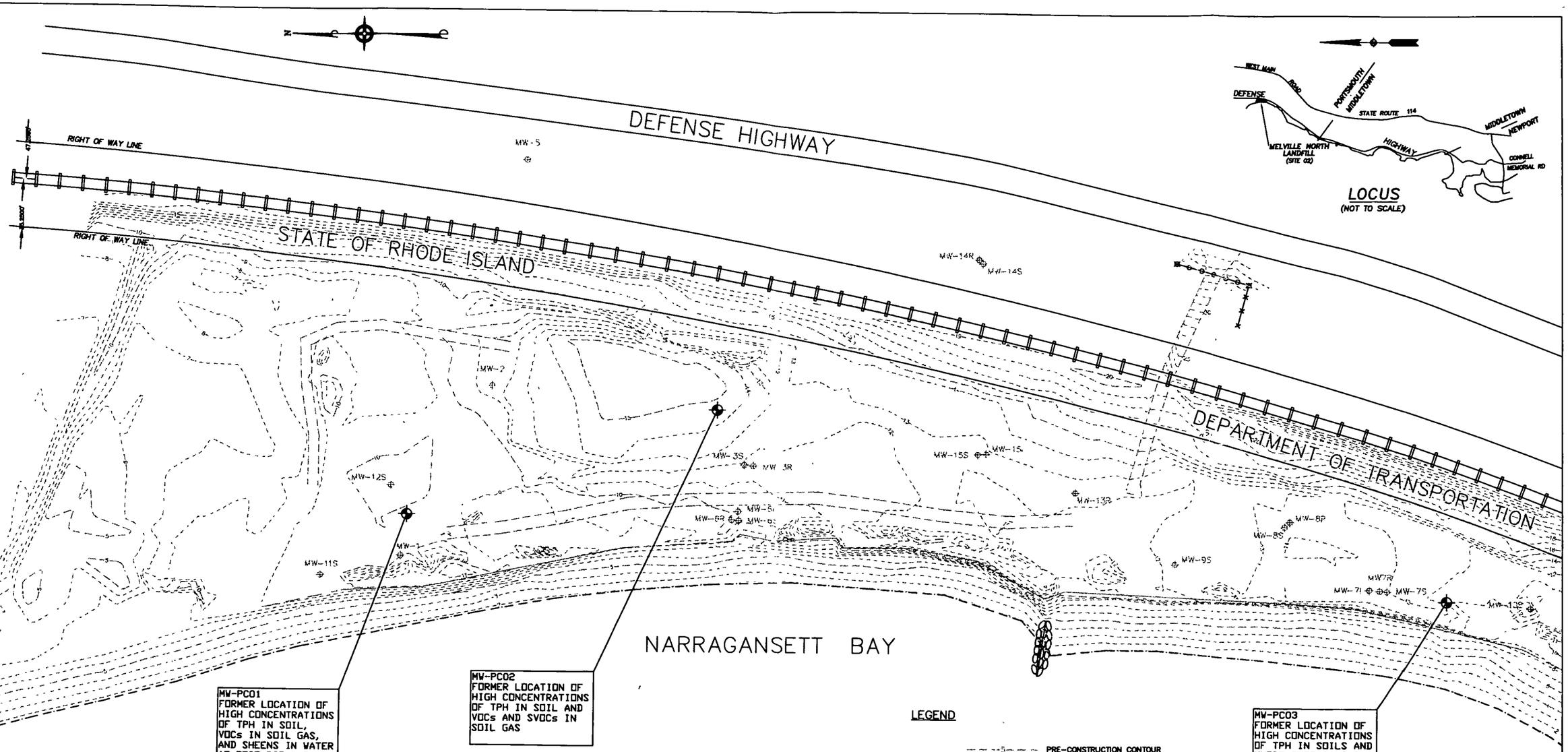
Three soil borings will be advanced by a drilling subcontractor using standard drive and wash drilling methods for installation of groundwater monitoring wells. Proposed approximate soil boring and monitoring well locations are presented in Figure 3-1. Table 3-1 presents location-specific information and the rationale for monitoring well locations.

Soil borings will be advanced to the required depth using minimum 4.0-inch inside diameter temporary flush-joint steel casing. If visual or olfactory evidence is encountered during drilling that indicates contaminant presence, soil samples will be collected for VOC and TPH analysis as appropriate. Such observations will be recorded on boring logs and well construction logs provided in Appendix A. Soil samples will be collected by driving split-barrel samples ahead of the drilling casing as it is advanced through the overburden. The TtNUS field geologist will screen samples using an FID to evaluate presence of volatile contaminants.

Each soil boring will be completed as a monitoring well. Monitoring wells will feature a 2-inch ID screen set to intercept (monitor) the groundwater table with the top of the 10-foot screen set 2 to 3 feet above the observed groundwater table elevation observed by the field engineer/geologist. Size of materials used for filter pack and size of well screens will be selected to accommodate the soil conditions encountered at well locations. The wells will be developed a minimum of 2 days after installation, through pumping and surging, until the formation water is relatively free of fines. Readings of turbidity, pH, temperature, and specific conductance will be monitored during the development process. Wells will be developed until these parameters stabilize. Additional wells will be installed if indications of contaminants are found below the targeted well screen interval.

3.2 GROUNDWATER SAMPLING

TtNUS will collect static water level measurements and groundwater samples from the proposed monitoring wells. Groundwater samples will initially be collected in accordance with the procedure



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2. ELEVATION DATUM: MEAN LOW WATER, U.S. NAVY.
3. THE CONTOUR INTERVAL IS ONE (1) FEET.
4. CONTROL POINTS 1 & 2 ARE LOCATED ALONG RAILROAD BASELINE, EACH FOUND APPROXIMATELY 1 FOOT BELOW SURFACE.

PROPOSED POST-CLOSURE MONITORING WELLS			
FORMER MELVILLE NORTH LANDFILL			
PORTSMOUTH, RHODE ISLAND			
DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	S. PARKER	DATE:	MARCH 6, 2003
SCALE:	AS NOTED	FILE NO.:	DWG\5152\0481\FIG_3-1.DWG

FIGURE 3-1

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TABLE 3-1

MONITORING WELL LOCATION/DEPTH RATIONALE
WORK PLAN FOR GROUNDWATER MONITORING
FORMER MELVILLE NORTH LANDFILL
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Monitoring Well No.	Location/Depth Rationale
MW-PC01	Located on the north side of the Melville North Landfill between former monitoring wells MW-12S, MW-11S and MW-1, this monitoring well will be placed at the location of former high concentrations of TPH in soil, VOCs in soil gas, and sheens in water at test pit TP12 prior to removal actions completed in 2000. This boring will be advanced to a maximum depth of 25 feet below ground surface (bgs). The anticipated depth to the water table in the area is estimated to be 5 to 8 feet bgs.
MW-PC02	Located in the central area of the Melville North Landfill near former monitoring wells MW-3S and MW-3R, this monitoring well will be placed at the location of former high concentrations of TPH in soil and VOCs and SVOCs in soil gas prior to removal actions completed in 2000. This boring will be advanced to a maximum depth of 25 feet below ground surface (bgs). The anticipated depth to the water table in the area is estimated to be 5 to 8 feet bgs.
MW-PC03	Located on the south side of the Melville North Landfill near the former MW-7 monitoring well cluster, this monitoring well will be placed at the location of former high concentrations of TPH in soils and where sheens were evident in well purge water prior to removal actions completed in 2000. This boring will be advanced to a maximum depth of 25 feet below ground surface (bgs). The anticipated depth to the water table in the area is estimated to be 5 to 8 feet bgs.

outlined in EPA's Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells (EPA SOP No. GW 001). Duplicate samples will then be collected by purging and sampling with bailers as per RIDEM requirements. All samples will be shipped to an off-site laboratory for analysis.

Work elements for the monitoring well sampling activity include the following:

- Prior to purging, the depth to groundwater (measured from the top of casing) and the bottom depth of the monitoring well will be recorded to the nearest 0.01 foot using an oil-water interface probe to determine if light non-aqueous-phase liquids (LNAPL) are present. The probe will be decontaminated prior to use and between use in each well according to the procedures outlined in Section 3.5. The presence of LNAPL and the depth to groundwater will be recorded on the groundwater level measurement sheet (Appendix A). If any measurable NAPL is measured, the geologist/engineer will contact the TtNUS Project Manager, who will notify the landowner and RIDEM; and samples of the NAPL will be collected using bailers.

- Purge wells, using bailers and peristaltic pumps, and measure pH, ORP, temperature, specific conductance, dissolved oxygen, turbidity, water level and pumping rate every 3 to 5 minutes (or as appropriate) during extraction of water from the well. Purging will be considered complete when pH, specific conductivity and turbidity parameters have stabilized (three consecutive measurements within 10 percent). Instrument readings will be recorded on the sample log sheet (Appendix A). If the monitoring well dewaters while pumping, the monitoring well will be allowed to recharge, until a minimum of two casing volumes is purged prior to collecting samples;

- The pH, ORP, temperature, specific conductance, turbidity, and dissolved oxygen of each sample will be measured in the field using a portable multi-parameter water quality meter. The water sample will be dispensed directly into a dedicated sample container for the meter, and the readings will be recorded on the sample log sheet.

The multi-parameter meter and dedicated sample container will be triple-rinsed with deionized water after each use.

Groundwater samples will initially be collected using low flow methods and equipment. Following completion of low flow sampling, wells will be re-purged and samples will be re-collected using bailers, per RIDEM requirements.

Groundwater samples will be collected in order of decreasing volatility: VOCs, TPH, SVOCs, pesticides/PCBs, and metals. The samples will be preserved immediately after collection. For collection of duplicate samples, one full set of sample containers for the original sample is filled, and then one full

TABLE 3-2
SUMMARY OF SAMPLE AND ANALYSIS REQUIREMENTS - SPRING 2003
WORK PLAN FOR GROUNDWATER MONITORING
FORMER MELVILLE NORTH LANDFILL
NAVAL STATION NEWPORT, NEWPORT RHODE ISLAND

Sample Media	Analysis	Required Containers (1)	Holding Times	Preservative	Number of Samples				
					Field Samples	Field Duplicates	Rinsate Blanks	Trip Blanks	TOTAL
Groundwater	VOCs, Method 8260B	3 - 40 ml vial	14 Days	HCl to pH <2, cool to 4° c	6	2	2	1	**11**
	TPH, Method 8015B - DRO/GRO	2 - 1 Liter Amber jar	14 Days	5ml of 1:1 HCL; Cool to 4° c	6	2	2	0	**10**
	SVOCs, Method 8270	2 - 1 Liter Amber jar	7 Days	Cool to 4° c	6	2	2	0	**10**
	Metals (Total), Method 6010	1 - 1 Liter polyethylene	28 days	HNO_3 to pH<2	6	2	2	0	**10**
	Pesticides/PCBs, Method 8080	1 - 1 Liter Amber jar	14 Days	Cool to 4° c	6	2	2	0	**10**
Soil	VOCs, Method 8260B	2 - 40 ml vials	14 Days	Methanol, Cool to 4° c	*	*	*	*	*
	TPH, Method MADEP EPH by GC/FID	8 oz. Amber jar	14 Days	Cool to 4° c	*	*	*	*	*

(1) - Minimum volume required for analysis, each sample

(*) - Soil samples to be collected if conditions indicate contaminants present (see text)

set of duplicate sample containers is filled. Samples will then be documented, packaged and shipped to the laboratory for chemical analysis.

Groundwater samples will be analyzed for VOCs (Method 8260B), TPH (Method 8015B –DRO/GRO), SVOCs (Method 8270), pesticides/PCBs (Method 8080), and total metals (Method 6010). Table 3-2 specifies groundwater analytical methods and the anticipated sample and quality control samples estimated for collection and analysis. This table also presents maximum sample holding times, and sample container and preservation requirements. Purge water and decontamination water will be managed as discussed in Section 3.3.

Following completion of the well installations, a survey will be performed by TtNUS personnel, using established control points, to locate the three sampling locations (wells). TtNUS will determine horizontal sample locations by GPS survey.

3.3 INVESTIGATION-DERIVED WASTE (IDW) MANAGEMENT

Any drill/purge water and well development water generated will require containerization as IDW in 55-gallon drums (and stored in a central area at the site). If conditions require it, a licensed disposal subcontractor will conduct IDW removal and disposal. If contaminants are not present at levels requiring offsite disposal, this material will be returned to the ground at the site.

3.4 WELL ABANDONMENT/REMOVAL

After completion of the groundwater investigation program, all monitoring wells installed as part of this effort will be abandoned and removed in their entirety.

Wells shall be abandoned/removed by removing the protective casing and then overdrilling the entire depth of the well using a solid stem auger larger than the outside diameter of the borehole (anticipated to be 4 inches). The overdrilled hole will be backfilled with a bentonite-soil mix. Following overdrilling, all excess materials will be removed from the site.

3.5 DECONTAMINATION

This section provides guidelines for decontamination of equipment used during the field investigation. Personnel decontamination issues will be discussed in the site-specific HASP.

3.5.1 Decontamination During Drilling

Equipment used by the drilling subcontractor(s) shall be decontaminated prior to use at the Site, between work locations and prior to leaving Site. Decontamination of equipment will be performed using a high-pressure steam wash. The drilling subcontractor(s) will be responsible for designing and locating the decontamination pads that will be used to decontaminate their equipment.

Decontamination of the drilling apparatus will be performed using a high-pressure steam wash. The drilling specification will require the drilling subcontractor to have sufficient downhole equipment available so as not to impede progress of work. All downhole drilling, sampling, and testing equipment for the HSA drilling rig and the back end of the rig must be steam cleaned prior to beginning drilling, between boring locations, and any time the rig leaves the drill site prior to finishing a boring and at the conclusion of the drilling program.

3.5.2 Decontamination Procedures During Groundwater Sampling

All non-disposable sampling and testing equipment that comes in contact with the sample medium will be decontaminated to prevent cross-contamination between sampling points, as described below:

1. Brush to remove gross contamination
2. Potable water and detergent (Alconox or Liquinox) wash and scrub with brush
3. Rinse with potable water
4. Rinse with distilled water (analyte free)
5. Rinse with 2-propanol
6. Rinse with de-ionized water
7. Air dry on aluminum foil or in a strainer
8. Wrap in aluminum foil, shiny side out for transport (or if not being used immediately)

3.5.3 Groundwater Pumps

Peristaltic pumps will be used to obtain samples from the monitoring wells installed at the Site. Peristaltic pumps do not require decontamination procedures, since the tubing which contacts the groundwater is changed for each well to be sampled.

3.5.4 Instrument and Meter Decontamination

Water level meters and oil-water interface probes will be decontaminated using the following steps:

1. Rinse with potable water
2. Rinse with 2-propanol
3. Rinse with deionized water

4.0 QUALITY ASSURANCE PROJECT PLAN

This QA/QC section includes information on project quality objectives, project action limits, measurement performance criteria, sample collection documentation requirements, the sample identification system, sample handling and custody procedures, analytical method requirements, sampling and analytical quality control requirements, analytical documentation and data management, data validation and verification requirements and procedures, and QA assessment and management efforts.

Achieving the study objectives for this RI requires that the data collected from the field conform to an appropriate level of quality, adequate to be used for baseline risk assessments. The quality of a data set is measured by certain characteristics of the data, which are described in this section.

4.1 PROBLEM DEFINITION/BACKGROUND

As stated in Section 1.0, the purpose of this groundwater investigation is to make a determination of any presence and nature of oil and hazardous materials in groundwater at the Former Melville North Landfill Site following soil and waste removal actions conducted in 1999 and 2000. Sample analytical results will be compared to RIDEM GB groundwater objectives (RIDEM DSR-01-83, [as amended 1996,] Section 8 03, Table 4), which is consistent with the data evaluations conducted for the site investigation (TtNUS, 1997). Exceedance of these standards may indicate continued presence of contaminants that may require additional evaluation and/or removals in the future.

4.1.1 Data Quality Objectives and Criteria for Measurement Data

DQO development focuses on identifying the end use of the data to be collected and on determining the degree of certainty with respect to precision, accuracy, representativeness, completeness, and comparability necessary to satisfy the intended use of the data. The data to be collected in this investigation will be used to determine the presence of contaminants exceeding RIDEM GB standards. This information may also be used for decision-making related to future site development.

4.1.2 Special Training Requirements/Certification

To comply with the OSHA requirements, all TtNUS employees and subcontractors working on site in hazardous waste site investigations will receive the 40-hour health and safety training course prior to beginning work on the Site. Supervisory personnel are required to receive the 8-hour supervisor training.

All field team members will review the associated work plan, this Work Plan; the HASP identified in Section 1.0 of this document, and all applicable SOPs. In addition, a field orientation meeting will be held with the Project Manager, the Lead Chemist, and the Office Health and Safety Manager prior to initiating the sampling event to familiarize field team members with the scope of the field activities.

Project team personnel are trained in the specific procedures to be followed during the execution of the work, including but not limited to project QA/QC requirements, soil and groundwater sampling, chain-of-custody procedures, document control, test and inspection methods, calibration, and in particular, the general provisions of this work plan and its supporting procedures and guidelines.

4.1.3 Documentation and Records

Documentation to be used in the field investigation is described below.

4.1.3.1 Site Log Book

A bound site logbook (notebook) will be maintained by the FOL. The FOL or designee will record all information related to sampling or field activities. This information will include sample time, weather conditions, unusual events, field measurements, and descriptions of photographs, etc. Additional field logbooks (notebooks) will be used to cover specific tasks, i.e. drilling rig logbooks; however, the site logbook will contain a summary of each days activities, and will reference the other field notebooks and field forms when applicable. The requirements of the site logbook are outlined in TtNUS SOP SA-6.3.

4.1.3.2 Sample Log Sheets

The field team will complete sample log sheets for the soil and aqueous samples collected. The sample log sheet forms contain information about sample location, date, and time of the sample collection, as well as a sample description, analysis, and sample container lot number. Sample logsheet forms are included in Appendix A.

4.1.3.3 Packing List/Chain-Of-Custody Record and Custody Seal

The original packing list/chain-of-custody record is enclosed in plastic and secured to the inside lid of the sample cooler for shipment to the laboratory. If multiple coolers are required to ship a single set of samples, the chain-of-custody form will be included in the cooler labeled "cooler #1 of X" a copy of the chain of custody form is retained for the project files. Signed and dated custody seals are placed across

the cooler openings. Copies of the chain of custody forms and the custody seals are contained in Appendix A.

The laboratory custodian receiving the samples signs and dates the chain-of-custody records to acknowledge receipt of the samples. The laboratory is then responsible for maintaining sample custody records and returning the original chain-of-custody form with the data analysis results.

4.1.3.4 Additional Field Forms

Additional field forms will be used, including field instrument calibration logs, boring logs, well construction logs, liquid phase data sheets, and head space screening logs (see Appendix A).

4.2 MEASUREMENT/DATA ACQUISITION

This section describes the sampling methods, handling, analytical requirements and methods, and QA/QC requirements for this project. In addition, information about the instrumentation type, maintenance, calibration, and data management is also described.

4.2.1 Sampling Methods Requirements

Groundwater sample collection, including sampling methods and equipment decontamination procedures, are discussed in Section 3.0. These methods are presented to comply with procedures for groundwater testing as described in the RIDEM regulations, including, but not limited to RIDEM Remediation Regulations (1993) and Rules and Regulations for Groundwater Quality (1993).

4.2.2 Sample Handling and Custody Requirements

Custody of samples will be maintained at all times and documented in the chain-of-custody forms. Chain of custody begins at the time the sample is collected and is maintained by storing the samples on ice in coolers that are locked or are sealed with a custody seal. The chain-of-custody forms are shipped to the laboratory with the samples. Each sample collected will be assigned a unique sampling tracking number.

The sample location identification system is based on TtNUS SOP CT-04. The preferred sample location tracking number will consist of a four- to five-segment, alphanumeric code that identifies the site, sample medium and location. The sample containers, preservatives, and the maximum allowable sample holding times before sample extraction, digestion, or analysis are presented in Table 3-2.

4.2.3 Analytical Methods Requirements

A summary of laboratory analytical methods is presented in Table 3-2. These methods are selected based on the best industry practices and for compliance with RIDEM remediation regulations. In addition, TtNUS will collect pH, ORP/Eh, temperature, specific conductance, dissolved oxygen and turbidity field measurements during groundwater sample collection as described in Section 3.0.

The TtNUS technical specifications for laboratory analysis contain the method of analysis (as presented in Table 3-2 and 3-3), instrumentation, detection limits, QC criteria, corrective action measures, sampling schedules, sample numbers, communication contact, and delivery requirements for analytical services.

4.2.4 Quality Control Requirements

The quality control procedures refer to both field and laboratory control operations. The results from analysis of field and laboratory QC samples are used to document data quality and to control the data acceptance within previously established check limits in order to meet the DQO requirements for the project. Laboratory quality control criteria requirements will include laboratory blank acceptance, instrument calibration, initial and continuing calibration, instrument performance check, reagent standardization checks, laboratory precision requirements, and other analytical method-compliant QC results.

4.2.4.1 Standard Operating Procedures

This section describes the applicable TtNUS and U.S. EPA Region I SOPs to be utilized under this SAP. While EPA SOPs do not directly apply, these procedures are recognized as a best practice for collection of environmental groundwater samples.

TtNUS SOPs:

CT-05 - Database Records and Quality Assurance;
SA-1.1 - Groundwater Sample Acquisition and Onsite Water Quality Testing;
SA-6.1 - Non-Radiological Sample Handling;
SA-6.3 - Field Documentation; and
SA-7.1 - Decontamination of Field Equipment and Waste Handling.

RIDEM Procedures:

RI 12-100-006 – Required Monitoring Well Construction Standards and Abandonment Procedures.

EPA SOPS:

GW # 001 – Revision 2, Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells.

4.2.4.2 Field Quality Control

In addition to periodic calibration of field equipment and appropriate documentation, quality control samples will be collected or generated during sampling activities. Quality control samples include field duplicates and blanks. Each type of field quality control sample is defined below.

Rinsate Blank: Rinsate blanks are obtained under representative field conditions by running analyte-free deionized water through sample collection equipment after decontamination and placing it in the appropriate sample containers for analysis. Sample preservatives must be added to the rinsate blanks. These samples are used to assess the effectiveness of decontamination procedures. Only one rinsate blanks will be required since fewer than ten samples will be collected.

Trip Blanks: Trip blanks are prepared in the laboratory (or in the field, in an area outside the zone of contamination) prior to the sampling event. Sample preservatives are used when required for the specific analysis. Trip blanks are packaged and shipped with the field samples. The results obtained from trip blank analysis are used to assess cross contamination during sample transport and storage. For this project, one VOC trip blank will be required.

Field Duplicates: Field duplicates are typically submitted at the rate of one for every 10 samples per matrix. Field duplicates are collected as collocated samples. Collocated samples are collected by filling water sample containers one after the other, rather than by mixing a sample and then dividing it into two containers. Field duplicates provide precision information regarding homogeneity and distribution of the contaminants; they measure the bias of sub-sampling. For this project, one field duplicate will be collected and submitted since fewer than ten samples will be collected.

4.2.5 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

Maintenance and calibration is the process of providing the degree of care necessary to obtain high-quality production, ensuring the optimum useful life of fieldwork equipment. The process includes determining of the need for and performing preventative maintenance and rehabilitation.

Equipment, instruments, gauges, and other items requiring preventive maintenance will be serviced in accordance with the manufacturer's specified recommendations. The manufacturer's procedures identify

the schedule for servicing critical items in order to ensure proper operations and to maximize the measurement system usability.

When equipment and instruments are in use in the field or at sites, routine maintenance may be required. Experienced field personnel will perform routine maintenance or service in accordance with the manufacturer's instructions. If the equipment or instrument cannot be serviced in the field, then these items must be returned to the manufacturer or their representative for proper service.

4.2.6 Instrument Calibration and Frequency

The equipment used for data collection, laboratory analysis, and health and safety monitoring is calibrated and maintained according to the manufacturer's instructions.

Monitoring instruments that will be used during the field investigation activities are listed below. The following instruments will be calibrated prior to daily use; calibration will be checked at the end of the day:

- Photoionization detector (PID);
- YSI 6820 Multi parameter meter, including:
  - Temperature;
  - Specific Conductivity;
  - ORP/EH;
  - Dissolved Oxygen; and
- Turbidity Meter

During calibration, an appropriate maintenance check will be performed on each piece of equipment. If damaged or failed parts are identified during the daily maintenance check and it is determined that the damage could have an impact on the instrument's performance, the instrument will be removed from service until the identified parts are repaired or replaced.

Calibration is documented on an Equipment Calibration Log sheet, which is presented in Appendix A.

4.2.7 Inspection/Acceptance Requirements for Supplies and Consumables

Supplies and consumables will meet the requirements of the specific task. The TtNUS Equipment Manager and the FOL perform the inspection of consumables and supplies for use in the project.

The TtNUS Quality Assurance Manual and the TtNUS Procurement Policies will be applied for procuring, inspecting, and accepting procured supplies and consumables. The Equipment Manager is responsible for inspecting all instrumentation received for NAVY support activities.

4.2.8 Data Management

Chemical/analytical data generated during the study will be reduced to a concise form. The analytical results provided by the laboratory will be reduced using an existing computer program developed by TtNUS specifically for chemical databases. The computer operator checks the data entered into the program and the printouts are checked against the original laboratory sheets by a chemist.

After the data is converted to Microsoft Access format, the data will be checked against the chain of custody for consistency; corrections will be made as necessary. Analytical parameter names will be checked against an existing library table. Laboratory QC sample results will be sequestered in a separate table.

Draft data summary tables will be printed. During data validation, the summary tables will be marked up to include data qualifiers, corrections, or other appropriate edits or notations. The marked-up summary tables will be used to edit the database. Final data summary validation tables will be printed for inclusion in the groundwater investigation report. Laboratory data reports will be appended to the groundwater investigation report.

5.0 REPORTING

Following the completion of the field sampling and analytical work described in Sections 3 and 4 of this Work Plan, the results will be described in the form of a letter report that will describe:

- Well installation and sampling efforts;
- Observations and data collected during field activities;
- Results from sample analysis;
- Qualifications (if any) from the data review.

The report will be provided following completion of the spring sampling effort discussion of data with the Navy, the landowner, and RIDEM. Data will initially be compared to RIDEM GB groundwater standards as is consistent with the SI conducted in 1997. In addition, the Navy will discuss with RIDEM other risk-based criteria (human health and ecological) that may be appropriate for data comparison.

5.1 SCHEDULE

The following table presents a list of actual and projected completion dates for activities associated with the implementation of this work plan.

Task	Date
Submit Work Plan to RIDEM (Actual)	3/24/03
RIDEM Review (Actual)	3/24/03 –5/8/03
Final Work Plan (Actual)	5/8/03 – 5/30/03
Complete Access Agreement (Projected)	6/6/03
Well Installation (Projected)	6/16/03 – 6/20/03
Groundwater Sampling (Projected)	6/23/03 – 6/27/03
Groundwater Sampling Report (Projected)	7/31/03

APPENDIX A
FIELD DOCUMENTATIONS FORMS

TETRA TECH NUS INC.

FIELD MODIFICATION RECORD

Site Name: _____ Location: _____

Project Number: _____ Task Assignment: _____

To: _____ Location: _____ Date: _____

Description: _____

_____

_____

_____

Reason for Change: _____

_____

_____

Recommended Action: _____

_____

_____

Field Operations Leader (Signature): _____ Date: _____

Disposition/Action:

_____

_____

_____

Project Manager (Signature): _____ Date: _____

Distribution:

		Others as Required:
Program Manager:	_____	
Project Manager:	_____	_____
Quality Assurance Officer:	_____	_____
Field Operations Leader:	_____	_____
Project File:	_____	_____

TETRA TECH NUS, INC.

PROJECT NAME: _____ RIG NUMBER & TYPE _____

PROJECT NUMBER: _____ DATE: _____

LOCATION: _____ INSPECTED BY: _____

	ITEM	√	COMMENTS
1	Number of Emergency shutdown switches_____ All personnel knowledgeable of their location (s). Switches have been tested prior to commencement of drilling operations		
2	Steel cables are not frayed		
3	Ropes are not frayed		
4	Hydraulic fluids, and lubricants are not leasking		
5	Equipment with proper guards in place (chains to cecure high-power air lines in the event of a break)		
6	Use of improper tools, pins, or other devices in poor condition		
7	Using worn air or hydraulic lines		
8	Cleaning-up the work site		
9	Storing fuels or other fluids in proper containers		
10	Hard hats, safety eyewear, steel toe/shank boots, hearing protection, Gloves, tyvek worn by driller/helper		
11	Proper protection equipment required by the Health & Safety Plan		
12	Decontamination Equipment		
13	Vehicle warning alarms (horn, mast, and back-up alarms)		
14	Fire extinguishers; fully charged and accessible		
15	Electrical wiring and switches		
16	Documentation of each driller's compliance with OSHA Health & Safety Training requirements		

TtNUS Form 0056

The FOL and SSO can request demonstration that the equipment is functioning properly.

TETRA TECH NUS. INC.

FIELD INSTRUMENT CALIBRATION LOG

INSTRUMENT NAME: _____ MODEL No.: _____

SERIAL No.: _____ DECAL No.: _____ TETRA TECH NUS CHARGE No. _____

CALIBRATION DATE	INITIAL READING	PROCEDURE	FINAL READING	SIGNATURE	COMMENTS

TtNUS Form 0007

BORING LOG FOR:
PROJECT NO.
LOGGED BY:
DRILLED BY (Company/Driller):
GRD. SURFACE ELEVATION:

TRANSCRIBED BY:
ELEVATION FROM:

BORING NO.:
START DATE:
COMPLETION DATE.
MON. WELL NO.:
CHECKED BY:

DEPTH (FEET)	BLOWS PER 6"	SAMP REC. / SAMP LENG	SAMPLING TIME & SAMPLE NO (QA/QC STATUS)	DEPTH MAT'L CHG./ WELL PROF'L	SOIL DENSITY/ CONSIS. or ROCK HARD	CLR	MATERIAL CLASSIFICATION	USCS or ROCK BRKN	REMARKS (moisture condition, odors; geological classification, rock weathering, etc)	FIELD SCREENING DATA *METHOD* = [FID, (PPM)]

TYPE OF DRILLING RIG
METHOD OF ADVANCING BORING
METHOD OF SOIL SAMPLING
METHOD OF ROCK CORING.
GROUNDWATER LEVELS:
OTHER OBSERVATIONS

BORING NO

Tetra Tech NUS, Inc.

PAGE OF

Ttnus Form 0018

TETRA TECH NUS, INC.

JAR HEADSPACE ANALYSIS LOG

SITE NAME: _____

SITE LOCATION: _____

PROJECT NO./CTO NO.: _____

SAMPLE LOCATION: _____

INSTRUMENT: _____

SERIAL NO.: _____

MODEL NO.: _____

SAMPLE PREP METHOD[1] _____

HEADSPACE ANALYST: _____

DATE: _____

SAMPLE TYPE[2]/NUMBER	SAMPLE DEPTH (FEET)	READING (ppm)	COMMENTS

Tt Form 0008

1) (a) ambient temp
(h) heated (air)
(w) hot water bath

2) Type of Sample
SB Soil Boring
SD Sediment Sample
GW Groundwater Sample
TP Test Pit Sample
SS Soil Sample

OVERBURDEN MONITORING WELL CONSTRUCTION LOG

TETRA TECH NUS, INC.

PROJECT NAME: _____ PROJECT NO: _____

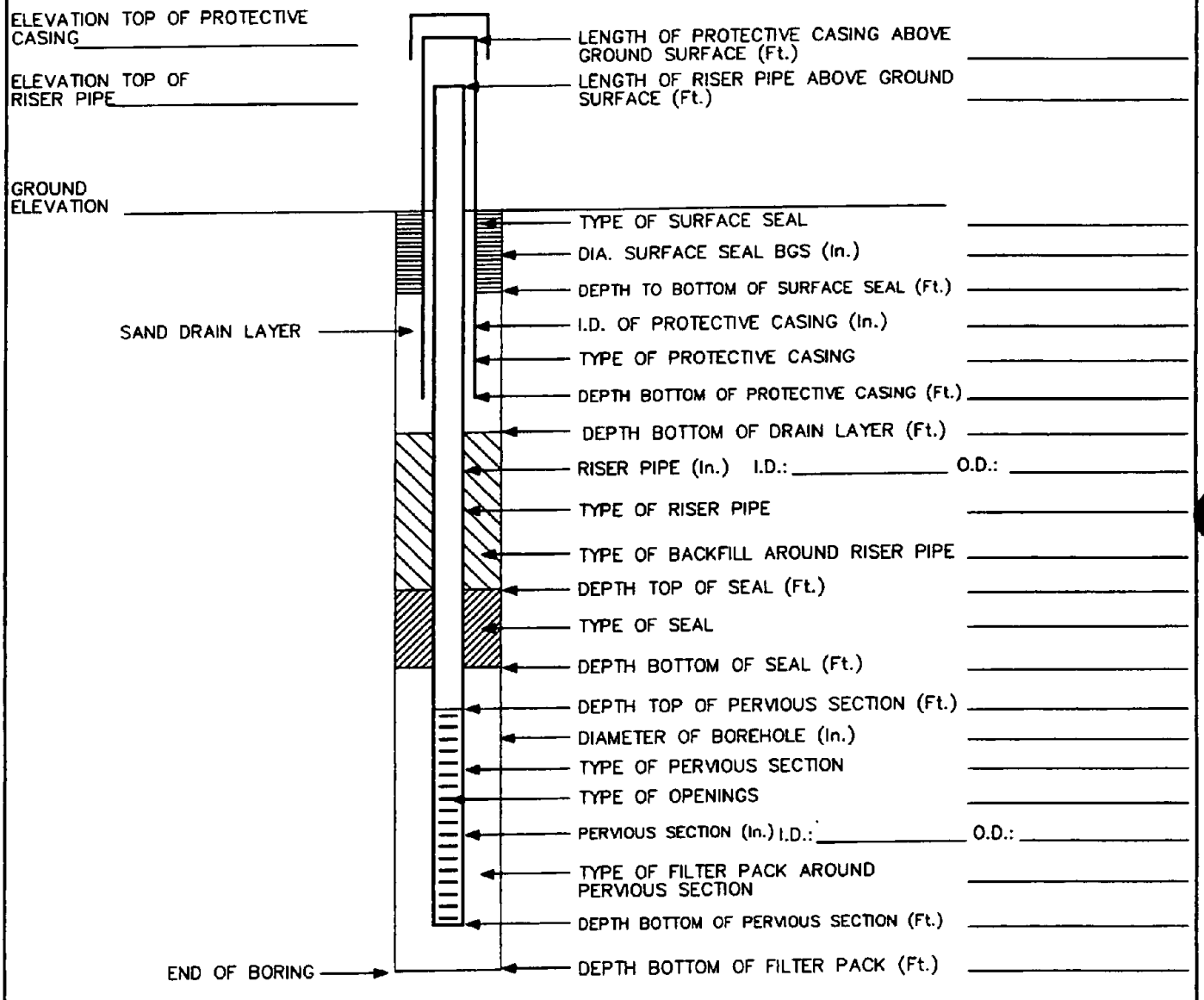
PROJECT LOCATION: _____ WELL NO: _____

CLIENT: _____ BORING NO: _____

CONTRACTOR: _____ DRILLER: _____ BORING LOCATION: _____

LOGGED BY: _____ DATE: _____

CHECKED BY: _____ DATE: _____



GENERAL NOTE:

1. Entry of 0.00 for Ground Elevation, Elev. Top of Riser Pipe & Elev. Top of Protective Casing Indicates that Surveyed Ground Elevation Not Available

TETRA TECH NUS, INC.

WELL DEVELOPMENT DATA SHEET

Well No.: _____

PROJECT: _____ DATE: _____

PROJECT NO.: _____ WEATHER: _____

PERSONNEL: _____

Well Screen Depth: _____ / _____ ft. bgs

H&S Monitoring Instrument Reading _____

Pump Type/Material: _____

Pump Intake Depth: _____

Total Purge Volume = _____(gal)

Data Recorded By: _____

Time	Water Level ft below top PVC	Volume mL	Flow Rate mL/min	Temp °C	pH	Sp Cond mS/cm	DO mg/L	Turbidity NTU	Comments

Tt NUS Form 0013

Page ___ of___

TETRA TECH NUS, INC.

SAMPLE LOG SHEET - "LOW FLOW" GROUNDWATER

Site Name: _____
Sample ID: _____

Tetra Tech NUS Job No./PMS _____
QC: _____(If applicable)

Sample Method: _____
Depth Sampled: _____Feet Screened Interval Depth _____feet
Sample Date & Time: ____/____/____ _____hours _____/Dup
Sampler(s): _____
Data Recorded By: _____ Signature: _____
Notes:

H&S Survey Meter _____ PPM Field Instrument Group A/B/C/D
Pre-pump insertion WL _____ ft Post - pump insertion WL _____ft

Analysis	Bottle Lot#	Analysis	Bottle Lot #	Analysis	Bottle Lot #

Clock Time 24hr	Water Depth below MP ft	Pump Dial 1	Purge Rate ml/min	Cum. Volume Purged liters	Temp °C	Spec. Cond. 2 uS/cm	pH	ORP/Eh3 mv	DO mg/L	Turbidity NTU	Comments

1. Pump dial setting (for example: hertz, cycle/min, etc.)
2. Siemens per cm (same as umhos/cm) at 25 °C.
3. Oxidation reduction potential (stand in for Eh).

Tt NUS Form 0009

TETRA TECH NUS, INC.

SAMPLE LOG SHEET - "LOW FLOW" GROUNDWATER

Site Name: _____

Sample ID: _____

Tetra Tech NUS Job No./PMS _____

QC: _____ (If applicable)

Clock Time 24hr	Water Depth below MP ft	Pump Dial 1	Purge Rate ml/min	Cum. Volume Purged liters	Temp ^{o}C	Spec. Cond. 2 uS/cm	pH	ORP/Eh3 mv	DO mg/L	Turbidity NTU	Comments

1. Pump dial setting (for example: hertz, cycle/min, etc.)
2. Siemens per cm (same as umhos/cm) at 25 ^{o}C.
3. Oxidation reduction potential (stand in for Eh).

Tt NUS Form 0009

TETRA TECH NUS, INC.

YSI 6820 MULTIPARAMETER METER

Serial No.: _____ Model No.: _____ Decal No.: _____ _____

Site Name: _____ Job No.: _____

Instrument is calibrated in accordance with Manufacturer's Instructions

DATE	Pre Calibration Readings	Post Calibration Readings	PM Check	Calibration STDs (lot #'s)	Signature	Remarks
Cond mS/cm						
pH = 4 0						
pH = 7 0						
pH = 10.0						
D.O. mg/l						
REDOX mV						
Turbidity 0 NTUs						
Turbidity 100 NTUs						
Temp °C						
Salinity 0/00						

DATE:						
Cond. mS/cm						
pH = 4.0						
pH = 7.0						
pH = 10.0						
D.O. mg/l						
REDOX mV						
Turbidity 0 NTUs						
Turbidity 100 NTUs						
Temp °C						
Salinity 0/00						

Tt NUS Form 0024

TETRA TECH NUS, INC.

SAMPLE COLLECTION SUMMARY RECORD

PROJECT NAME: _____ TETRA TECH NUS JOB NO./PMS: _____

SAMPLING EVENT: _____ CASE NO.: _____ DAS NO.: _____

DATE	TIME	SAMPLE LOCATION	FIELD QC							COMMENTS

Tt NUS Form 0012

TETRA TECH NUS, INC.

GROUNDWATER LEVEL MEASUREMENT SHEET

SITE INFORMATION

Site Name: _____ Municipality: _____

Project Number: _____ County: _____

Personnel: _____ State: _____

Date: _____ Street or Map Location: _____

(If Off-Site): _____

WEATHER CONDITIONS AND EQUIPMENT

Temperature Range: _____ Equipment No.: _____

Precipitation: _____ Equipment Number: _____

Barometric Pressure: _____ Latest Calibration Date: _____

Tidally-Influenced [ ] Yes [ ] No

Well or Piezometer Number	Date/Time	Elevation of Reference Point (Feet)*	Water Level Indicator Reading (Feet)*	Adjusted Depth (Feet)*	Groundwater Elevation (Feet)*

Tt NUS Form 0010

APPENDIX B
TETRA TECH NUS, INC. STANDARD OPERATING PROCEDURES

TETRA TECH NUS, INC.	STANDARD OPERATING PROCEDURES	Number GH-2.8	Page 1 of 12
		Effective Date 06/99	Revision 2
		Applicability Tetra Tech NUS, Inc.	
		Prepared	
Subject GROUNDWATER MONITORING WELL INSTALLATION		Approved D. Senovich	

TABLE OF CONTENTS

ATTACHMENTS

1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper monitoring well design, installation, and development.

2.0 SCOPE

This procedure is applicable to the construction of monitoring wells. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be determined during the project planning phases of the investigation, and any required permits must be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

3.0 GLOSSARY

Monitoring Well - A well which is screened, cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored. Some monitoring wells may be constructed as open boreholes.

Piezometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch-diameter plastic tubes to well points or monitoring wells.

Potentiometric Surface - The surface representative of the level to which water will rise in a well cased to the screened aquifer.

Well Point (Drive Point) - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a solid, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground with a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater injection and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples for water quality data.

4.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an xperienced and efficient labor force capable of performing all phases of proper monitoring well installation and construction. The driller may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Field Geologist - The field geologist supervises and documents well installation and construction performed by the driller, and insures that well construction is adequate to provide representative groundwater data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

5.0 PROCEDURES

5.1 Equipment/Items Needed

Below is a list of items that may be needed when installing a monitoring well or piezometer:

- Health and safety equipment as required by the Site Safety Officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted engineer's tape, water level indicator, retractable engineers rule, electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installation tools (sledge hammer, drop hammer, or mechanical vibrator; tripod, pip wrenches, drive points, riser pipe, and end caps).

5.2 Well Design

The objectives and intended use for each monitoring well must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for trace contaminants.
- Determining aquifer characteristics (e.g., hydraulic conductivity).

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, groundwater flow directions and potential well locations can be determined by an experienced hydrogeologist through the review of geologic data and the site terrain. In addition, data from production wells or other monitoring wells in the area may be used to determine the groundwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary investigative phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored interval must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the depths at which contaminants are present. Conversely, a fully penetrating well is usually not used to quantify or vertically locate a contaminant plume, since groundwater samples collected in wells that are screened over the full thickness of the water-bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of contamination in the water-bearing zone. The well diameter desired depends upon the hydraulic characteristics of the water-bearing zone, sampling requirements, drilling method and cost.

The decision concerning the monitored interval and well depth is based on the following (and possibly other) information:

- The vertical location of the contaminant source in relation to the water-bearing zone.
- The depth, thickness and uniformity of the water-bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (5 feet or less) are usually required where flow lines are not horizontal, (i.e., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring well depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs.

Standard monitoring well diameters are 2, 4, 6, or 8 inches. Drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch-diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open-hole bedrock monitoring wells are used. With smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced; however, the sampling devices that can be used are limited.

In specifying well diameter, sampling requirements must be considered (up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples), particularly if the monitored formation is known to be a low-yielding formation. The unit volume of water contained within a monitoring well is dependent on the well diameter as follows:

Casing Inside Diameter (Inch)	Standing Water Length to Obtain 1 Gallon Water (Feet)
2	6.13
4	1.53
6	0.68

If a well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Pumping tests for determining aquifer characteristics may require larger diameter wells (for installation of high capacity pumps); however, in small-diameter wells in-situ permeability tests can be performed during drilling or after well installation is completed.

5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "Schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength". Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation; risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive presentation on this topic). The two most commonly used materials are PVC and stainless steel. Properties of these two materials are compared in Attachment B. Stainless steel is a good choice where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, ease of manipulation, and widespread acceptance. The crushing strength of PVC may limit the depth of installation, but the use of Schedule 80 materials may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps required for sampling or testing. Due to this problem, the minimum well pipe size recommended for Schedule 80 wells is 4-inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe may corrode and release metal ions or chemically react with organic constituents, but this is considered a minor issue. Galvanized steel is not recommended where samples may be collected for metals analyses, as zinc and cadmium levels in groundwater samples may become elevated from leaching of the zinc coating.

Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints. Welded-joint steel casing is also acceptable. Glued PVC may release organic contaminants into the well, and therefore, should not be used if the well is to be sampled for organic constituents.

When the water-bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary, and the annular borehole space around the screened interval is artificially packed with an appropriately sized sand, selected based on formation grain size. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The site geologist

shall specify the combination of screen slot size and sand pack which will be compatible with the water-bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. For example, as a standard procedure, a Morie No. 1 or No. 10 to No. 20 U.S. Standard Sieve size filter pack is typically appropriate for a 0.020-inch slot screen; however, a No. 20 to No. 40 U.S. Standard Sieve size filter pack is typically appropriate for a 0.010-inch slot screen.

5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a medium- to coarse-grained poorly graded, silica sand and should relate to the grain size of the aquifer sediments. The quantity of sand placed in the annular space is dependent upon the length of the screened interval, but should always extend at least 1 foot above the top of the screen. At least 1 to 3 feet of bentonite pellets or equivalent shall be placed above the sand pack. Cement-bentonite grout (or equivalent) is then placed to extent from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally (i.e., no artificial sand pack installed). In this case, the natural formation material is allowed to collapse around the well screen after the well is installed. This method has been used where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets, extending to the surface. The grout effectively seals the remaining borehole annulus and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom upward, to prevent bridging, and to provide a better seal. In shallow boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of one or two assemblages of material, (e.g., cement and/or bentonite). A cement-bentonite grout, which is the most common type of grout used in monitoring well completions, normally is a mixture of cement, bentonite, and water at a ratio of one 90-pound bag of Portland Type I cement, plus 3 to 5 pounds of granular or flake-type bentonite, and 6-7 gallons of water. A neat cement consists of one ninety-pound bag of Portland Type I cement and 6-7 gallons of water. A bentonite slurry (bentonite and water mixed to a thick but pumpable mixture) is sometimes used instead of grout for deep well installations where placement of bentonite pellets is difficult. Bentonite chips are also occasionally used for annular backfill in place of grout.

In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets/chips or cement grout. A short (1- to 2-foot) section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is typically placed over the top of the well. This casing generally has a hinged cap and can be locked to prevent vandalism. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

A protective casing which is level with the ground surface (flush-mounted) is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter, manhole-type protective collar is set into the wet cement around the well with the top set level with or slightly above the pavement. An appropriately-sized id is placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

5.3 Monitoring Well Installation

Pertinent data regarding monitoring well installation shall be recorded on log sheets as depicted and discussed in SOP SA-6.3. Attachments to this referenced SOP illustrate terms and physical construction of various types of monitoring wells.

5.3.1 Monitoring Wells In Unconsolidated Sediments

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case of hollow-stem auger drilling, the augers will act to stabilize the borehole during well installation.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineer's rule to ensure proper placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, the sand pack can be installed. A weighted tape measure must be used during the installation procedure to carefully monitor installation progress. The sand is slowly poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur. Centralizers may be used at the geologist's discretion, one above and one below the screen, to assure enough annular space for sand pack placement.

After the sand pack is installed to the desired depth (at least 1 foot above the top of the screen), then the bentonite pellet seal (or equivalent), can be installed in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack. Pellets should be added slowly and their fall monitored closely to ensure that bridging does not occur.

The cement-bentonite grout is then mixed and tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between aquifers. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large-diameter boring through the upper aquifer, 1 to 5 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting a large-diameter casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for installation of the monitoring well as detailed for overburden monitoring wells. Sufficient time (determined by the field geologist), must be allowed for setting of the grout prior to drilling through the confined layer.

5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 –10 feet into bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout has cured, a smaller diameter boring is continued into bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. If a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be removed when the final well installation is completed.

5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen section is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be manually driven to depths exceeding 10 feet.

Direct push sampling/monitoring point installation methods, using a direct push rig or drilling rig, are described in SOP SA-2.5.

5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only small-diameter tubes extending to the surface. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross-contamination from sampling equipment. Four manufacturers of these samplers include Timco Manufacturing Company, Inc., of Prairie du Sac, Wisconsin, BARCAD Systems, Inc., of Concord, Massachusetts, Westbay Instruments Ltd. of Vancouver, British Columbia, Canada and the University of Waterloo at Waterloo, Ontario, Canada.. Each manufacturer offers various construction materials.

5.4 Well Development Methods

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity and temperature taken during development may yield information (stabilized values) regarding whether sufficient development has been performed. The selection of the well development method shall be made by the field geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

5.4.1 Overpumping and Backwashing

Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods, including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen.

5.4.2 Surging with a Surge Plunger

A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is aggressively moved up and down within the well to agitate the water, causing it to move in and out of the screens. This movement of water pulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

5.4.3 Compressed Air

Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus introducing air into the formation and reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping of the well is subsequently done using the air lift method.

5.4.4 High Velocity Jetting

In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire

screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

6.0 RECORDS

A critical part of monitoring well installation is recording of all significant details and events in the site logbook or field notebook. The geologist must record the exact depths of significant hydrogeological features, screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (see Attachments to SOP SA-6.3) shall be completed, ensuring the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information shall include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. Documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded, depending on whether the well is completed in overburden (single- or double-cased), as a cased well in bedrock, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The geologist shall calculate the annular space volume and have an idea of the quantity of material needed to fill the annular space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in or bridging of the backfill materials. Any problems with rig operation or down-time shall be recorded and may affect the driller's final fee.

7.0 REFERENCES

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U.S. EPA, 1980. Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities. Publication SW-611, Office of Solid Waste, U.S. EPA, Washington, D.C.

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ATTACHMENT A

RELATIVE COMPATIBILITY OF RIGID WELL CASING MATERIAL (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material						
	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless Steel 304	Stainless Steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Mineral Acid/ High Solids Content	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials:

1 Teflon®
2 Stainless Steel 316
3. Stainless Steel 304
4 PVC 1
5 Lo-Carbon Steel
6 Galvanized Steel
7 Carbon Steel

* Trademark of DuPont

RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material								
	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton®*	Silicone	Neoprene	Teflon®*
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/ High Solids Content	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

Preliminary Ranking of Semi-Rigid or Elastomeric Materials:

1 Teflon®
2 Polypropylene (PP)
3. PVC Flexible/PE Linear
4 Viton®
5 PE Conventional
6 Plexiglas/Lucite (PMM)
7 Silicone/Neoprene

* Trademark of DuPont

Source: Barcelona et al., 1983

ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength are not critical.
Weight	Relatively heavier.	Light-weight; floats in water.
Cost	Relatively expensive.	Relatively inexpensive.
Corrosivity	Deteriorates more rapidly in corrosive water.	Non-corrosive -- may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated hydrocarbons.
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work with in the field.
Preparation for Use	Should be steam cleaned if organics will be subsequently sampled.	Never use glue fittings -- pipes should be threaded or pressure fitted. Should be steam cleaned when used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized.	May sorb or release organic substances.

* See also Attachment A.

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		Effective Date 01/29/01	Revision 2
		Applicability Tetra Tech NUS, Inc.	
		Prepared Management Information Systems Department	
Subject DATABASE RECORDS AND QUALITY ASSURANCE		Approved D. Senovich	

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this document is to specify a consistent procedure for the quality assurance review of electronic and hard copy databases. This SOP outlines the requirements for establishment of a Database Record File, Quality Assurance review procedures, and documentation of the Quality Assurance Review Process.

2.0 SCOPE

The methods described in this Standard Operating Procedure (SOP) shall be used consistently for all projects managed by Tetra Tech NUS (TtNUS).

3.0 GLOSSARY

Chain-of-Custody Form - A Chain-of-Custody Form is a printed form that accompanies a sample or a group of samples from the time of sample collection to the laboratory. The Chain-of-Custody Form is retained with the samples during transfer of samples from one custodian to another. The Chain-of-Custody Form is a controlled document that becomes part of the permanent project file. Chain-of-Custody and field documentation requirements are addressed in SOP SA-6.1.

Electronic Database - A database provided on a 5.25" or 3.5" diskette or a laser disk. Such electronic databases will generally be prepared using public domain software such as DBase, RBase, Oracle, Visual FoxPro, Microsoft Access, Paradox, etc.

Hardcopy Database - A printed copy of a database prepared using the software discussed under the definition of an electronic database.

Sample Tracking Summary - A printed record of sample information including the date the samples were collected, the number of samples collected, the sample matrix, the laboratory to which the samples were shipped, the associated analytical requirements for the samples, the date the analytical data were received from the laboratory, and the date that validation of the sample data was completed.

4.0 RESPONSIBILITIES

Database Records Custodian - It shall be the responsibility of the Database Records Custodian to update and file the Sample Tracking Summaries for all active projects on a weekly basis. It shall be the responsibility of the Database Records Custodian to ensure that the most recent copies of the Sample Tracking Summaries are placed in the Database Records file. It shall be the responsibility of the Database Records Custodian to ensure that a copy of all validation deliverables is provided to the Project Manager (for placement in the project file). It shall be the responsibility of the Database Records Custodian to ensure that photocopies of all validation deliverables and historical data and reports (as applicable) are placed in the Database Records file.

Data Validation Coordinator - It shall be the responsibility of the Data Validation Coordinator (or designee) to ensure that the Sample Tracking Summaries are maintained by the Database Records Custodian. It shall be the responsibility of the Data Validation Coordinator (or designee) to ensure that photocopies of all data validation deliverables are placed in the applicable Database Records file by the Database Records Custodian.

Earth Sciences Department Manager - It shall be the responsibility of the Earth Sciences Department Manager (or equivalent) to ensure that all field personnel are familiar with the requirements of this Standard Operating Procedure (specifically Section 5.5).

FOL - It shall be the responsibility of the FOL (FOL) of each project to ensure that all field technicians or sampling personnel are thoroughly familiar with this SOP, specifically regarding provision of the Chain-of-Custody Forms to the Database Records Custodian. Other responsibilities of the FOL are described in Sections 5.4 and 5.5.

Management Information Systems (MIS) Manager - It shall be the responsibility of the MIS Manager to ensure that copies of original electronic deliverables (diskettes) are placed in both the project files and the Database Records File. It shall be the responsibility of the MIS Manager (or designee) to verify the completeness of the database (presence of all samples) in both electronic and hardcopy form in the Database Records File. It shall be the responsibility of the MIS Manager to ensure that Quality Assurance Reviews are completed and are attested to by Quality Assurance Reviewers. It shall be the responsibility of the MIS Manager to ensure that records of the Quality Assurance review process are placed in the Database Records File. It shall be the responsibility of the MIS Manager to ensure that both electronic and hardcopy forms of the final database are placed in both the project and the Database Record File. It shall be the responsibility of the MIS Manager to ensure that data validation qualifiers are entered in the database.

Furthermore, it shall be the responsibility of the MIS Manager to participate in project planning at the request of the Project Manager, specifically with respect to the generation of level of effort and schedule estimates. To support the project planning effort, the IMSM shall provide a copy of the MIS Request From included as Attachment A to the project manager. It shall be the responsibility of the MIS Manager to generate level of effort and budget estimates at the time database support is requested if a budget does not exist at the time of the request. The MIS Request Form shall be provided to the Project Manager at the time of any such requests. It shall be the responsibility of the MIS Manager to notify the Project Manager of any anticipated level of effort overruns or schedule noncompliances as soon as such problems arise along with full justification for any deviations from the budget estimates (provided they were generated by the MIS Manager). It shall be the responsibility of the MIS Manager to document an changes to the scope of work dictated by the Project Manager, along with an estimate of the impact of the change on the level of effort and the schedule.

Program/Department Managers - It shall be the responsibility of the Department and/or Program Managers (or designees) to inform their respective department's Project Managers of the existence and requirements of this SOP.

Project Manager - It shall be the responsibility of each Project Manager to determine the applicability of this SOP based on: (1) program-specific requirements, and (2) project size and objectives. It shall be the responsibility of the Project Manager (or designee) to ensure that the FOL is familiar with the requirements regarding Chain-of-Custody Form provision to the Database Records Custodian. It shall be the responsibility of the Project Manager (or designee) to determine which, if any, historical data are relevant and to ensure that such data (including all relevant information such as originating entity, sample locations, sampling dates, etc.) are provided to the Database Records Custodian for inclusion in the Database Records File. It shall be the responsibility of the Project Manager to obtain project planning input regarding the level of effort and schedule from the MIS Manager. It shall be the responsibility of the Project Manager to complete the database checklist (Attachment A) to support the level of effort and schedule estimate and to facilitate database preparation and subroutine execution.

Risk Assessment Department Manager - It shall be the responsibility of the Risk Assessment Department Manager to monitor compliance with this Standard Operating Procedure, to modify this SOP as necessary, and to take corrective action if necessary. Monitoring of the process shall be completed on a quarterly basis.

Quality Assurance Reviewers - It shall be the responsibility of the Quality Assurance Reviewers to verify the completeness of the sample results via review of the Chain-of-Custody Forms and Sample Tracking Summaries. It shall be the responsibility of the Quality Assurance Reviewers to ensure the correctness of

the database via direct comparison of the hardcopy printout of the database and the hardcopy summaries of the original analytical data (e.g., Form Is provided in data validation deliverables). Correctness includes the presence of all relevant sample information (all sample information fields), agreement of the laboratory and database analytical results, and the presence of data validation qualifiers.

Quality Manager - It shall be the responsibility of the Quality Manager to monitor compliance with this Standard Operating Procedure via routine audits.

5.0 PROCEDURES

5.1 Introduction

Verification of the accuracy and completeness of an electronic database can only be accomplished via comparison of a hardcopy of the database with hardcopy of all relevant sample information. The primary purposes of this SOP are to ensure that 1) all necessary hardcopy information is readily available to Quality Assurance Reviewers; 2) ensure that the Quality Assurance review is completed in a consistent and comprehensive manner, and; 3) ensure that documentation of the Quality Assurance review process is maintained in the project file.

5.2 File Establishment

A Database Record file shall be established for a specific project at the discretion of the Project Manager. Initiation of the filing procedure will commence upon receipt of the first set of Chain-of-Custody documents from a FOL or sampling technician. The Database Record Custodian shall establish a project-specific file for placement in the Database Record File. Each file in the Database Record File shall consist of standard components placed in the file as the project progresses. Each file shall be clearly labeled with the project number, which shall be placed on the front of the file drawer and on each and every hanging file folder relevant to the project. The following constitute the minimum components of a completed file:

- Electronic Deliverables
- Sample Tracking Forms
- Chain-of-Custody Forms
- Data Validation Letters
- Quality Assurance Records

5.3 Electronic Deliverables

The format of electronic deliverables shall be specified in the laboratory procurement specification and shall be provided by the laboratory. The integrity of all original electronic data deliverables shall be maintained. This shall be accomplished via the generation of copies of each electronic deliverable provided by the laboratory. The original electronic deliverable shall be provided to the project manager for inclusion in the project file. A copy of the original electronic deliverable shall be placed in the Database Record File. The second copy shall be maintained by the MIS Manager (or designee) to be used as a working copy.

5.4 Sample Tracking Forms

Updated versions of the sample tracking form for each relevant project shall be maintained by the Database Record Custodian. The Sample Tracking Forms shall be updated any time additional Chain-of-Custody Forms are received from a FOL or sampling technician, or at any time that data are received from a laboratory, or at any time that validation of a given data package (sample delivery group) is completed. The Data Validation Coordinator shall inform the Database Record Custodian of the receipt of any data

packages from the laboratory and of completion of validation of a given data package to facilitate updating of the Sample Tracking Form. The Database Record Custodian shall place a revised copy of the Sample Tracking Form in the Database Record File anytime it has been updated. Copies of the updated Sample Tracking Form shall also be provided to the project manager to apprise the project manager of sample package receipt, completion of validation, etc.

5.5 Chain-of-Custody Forms

The Chain-of-Custody Forms for all sampling efforts will be used as the basis for (1) updating the Sample Tracking Form, and (2) confirming that all required samples and associated analyses have been completed. It shall be the responsibility of the FOL (or sample technician) to provide a photocopy of all Chain-of-Custody Forms to the Database Record Custodian immediately upon completion of a sampling effort. The Database Record Custodian shall then place the copies of the Chain-of-Custody Form(s) in the Database Record File. Upon receipt of a sample data package from an analytical laboratory, the Data Validation Coordinator shall provide a copy of the laboratory Chain-of-Custody Form to the Database Record Custodian. The Database Record Custodian shall use this copy to update the Sample Tracking Summary and shall place the copy of the laboratory-provided Chain-of-Custody Form in the Database Record File. The photocopy of the laboratory-provided Chain-of Custody Form shall be stapled to the previously filed field copy. Upon receipt of all analytical data, two copies of the Chain-of-Custody will therefore be in the file. Review of the Chain-of-Custody Forms will therefore be a simple mechanism to determine if all data have been received. Chain-of-Custody is addressed in SOP SA-6.1.

5.6 Data Validation Letters

All data validation deliverables (or raw data summaries if validation is not conducted) shall be provided for inclusion in both the Database Record File and the project file. If USEPA regional- or client-specific requirements are such that Form Is (or similar analytical results) need not be provided with the validation deliverable, copies of such results must be appended to the deliverable. It is preferable, although not essential that the validation qualifiers be hand-written directly on the data summary forms. The data validation deliverables (and attendant analytical summaries) will provide the basis for direct comparison of the database printout and the raw data and qualifiers.

5.7 Historical Data

At the direction of the Project Manager, historical data may also be included in a project-specific analytical database. In the event that historical data are germane to the project, hardcopy of the historical data must be included in the Database Record File. Historical data may be maintained in the form of final reports or as raw data. The information contained in the historical data file must be sufficient to identify its origin, its collection date, the sample location, the matrix, and any and all other pertinent information. All available analytical data, Chain-of-Custody Forms, boring logs, well construction logs, sample location maps, shall be photocopied by the Project Manager (or designee) and placed in one or more 3-ring binders. All information shall be organized chronologically by matrix. It shall be the responsibility of the Project Manager (or designee) to ensure that all inconsistencies between analytical data, Chain-of-Custody Forms, boring logs, sample log sheets, and field logbooks are identified and corrected. The Project Manager (or designee) shall decide which nomenclature is appropriate and edit, initial and date all relevant forms. Data entry may only be performed on information that has undergone the aforementioned editing process, thereby having a direct correlation between hardcopy information and what will become the electronic database.

6.0 RECORDS

Records regarding database preparation and quality assurance review include all those identified in the previous section. Upon completion of the database task, records from the file will be forwarded to the

Project Manager for inclusion in the project file, or will be placed in bankers boxes (or equivalent) for storage. The final records for storage shall include the following minimum information on placards placed on both the top and end of the storage box:

Database Record File
PROJECT NUMBER: ____
SITE NAME: _____
DATE FILED: __/__/__
SUMMARY OF CONTENTS ENCLOSED
BOX _ OF _

Project- or program-specific record keeping requirements shall take precedence over the record keeping requirements of this SOP.

ATTACHMENT A

MIS REQUEST FORM

Tetra Tech NUS, Inc

Project Name
CTO
Project Manager
Requestor:
Program/Client.
State/EPA Region.
Site Name(s) (Area, OU, etc).
Sampling Date(s):
Matrix. ☐ GW ☐ SO ☐ SD ☐ SW ☐ Other

Request Date
Date Data Available for Production:
Request in Support of
Database Lead
GIS Lead
Statistics Lead:
Risk Lead

Labels: ☐ Labels needed for an upcoming sampling event _____ Total # of Samples
_____ Estimated Hours
_____ Due Date
_____ Complete ETS Charge No.
_____ FOL
Additional Instructions:

Data Entry:
☐ Chemical data needs to be entered from hardcopy _____ Estimated # of Samples
☐ Chemical data needs to be formated electronically
☐ Field analytical data needs to be entered from hardcopy
☐ Geologic data needs to be entered from hardcopy
☐ Hydrology data needs to be entered from hardcopy
_____ Estimated Hours
_____ Due Date
_____ Complete ETS Charge No.
Additional Instructions:

Tables:
☐ Full Data Printout
☐ Summary of Positive Hits
☐ Occurance and Distribution ☐ with criteria
☐ Sampling Analytical Summary
☐ Other
_____ Estimated Hours
_____ Due Date
_____ Complete ETS Charge No.
Additional Instructions:

GIS:
☐ General Facility Location
☐ Site Location
☐ Potentiometric Contours/Groundwater Flow
☐ Sample Location Proposed
☐ Sample Location Existing
☐ Tag Map Single Round
☐ Tag Map Multiple Round
☐ Isoconcentrations
☐ Chart Map
☐ 3D Visualization
☐ EGIS CD
☐ Other:
_____ Estimated Hours
_____ Due Date
_____ Complete ETS Charge No.
Additional Instructions.

Statistics: ☐ Yes
_____ Estimated Hours
_____ Due Date
_____ Complete ETS Charge No
Additional Instructions:

Geostatistics: ☐ Yes
_____ Estimated Hours
_____ Due Date
_____ Complete ETS Charge No
Additional Instructions

TETRA TECH NUS, INC.	STANDARD OPERATING PROCEDURES	Number SA-1-1	Page 1 of 27
		Effective Date 06/99	Revision 4
		Applicability Tetra Tech NUS, Inc.	
		Prepared Earth Sciences Department	
Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING		Approved D. Senovich	

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this procedure is to provide general reference information regarding the sampling of groundwater wells.

2.0 SCOPE

This procedure provides information on proper sampling equipment, onsite water quality testing, and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology.

3.0 GLOSSARY

Conductivity – Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions, their total concentration, mobility, valence, and relative concentrations, and on temperature of measure. Conductivity is highly dependent on temperature and should be reported at a particular temperature, i.e., 20.2 mS/cm at 14C.

Dissolved Oxygen (DO) – DO levels in natural and wastewater depend on the physical, chemical, and biochemical activities in the water sample.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode, immersed in water, as referenced against a standard hydrogen electrode.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration.

pH Paper - Indicator paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution's pH.

Salinity – Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved slats in a given mass of solution. Note: most field meters determined salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or % (e.g., 35 ppt will equal 3.5%).

Turbidity – Turbidity in water is caused by suspended matter, such as clay, silt, fine organic and inorganic matter. Turbidity is an expression the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample.

4.0 RESPONSIBILITIES

Project Hydrogeologist - Responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), and equipment to be used, and providing detailed input in this regard to the project plan documents. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of the site sampling personnel.

Project Geologist - is primarily responsible for the proper acquisition of the groundwater samples. He/she is also responsible for the actual analyses of onsite water quality samples, as well as instrument calibration, care, and maintenance. When appropriate, such responsibilities may be performed by other qualified personnel (e.g., field technicians).

5.0 PROCEDURES

5.1 General

To be useful and accurate, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of analysis in order to keep any changes in water quality parameters to a minimum.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach shall be followed prior to sample acquisition:

1. All monitoring wells shall be purged prior to obtaining a sample. Evacuation of three to five volumes is recommended prior to sampling. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, extensive evacuation prior to sample withdrawal is not as critical.

2. For wells that can be purged dry, the well shall be evacuated and allowed to recover prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is required.

3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of the following techniques shall be used to minimize this possibility:

   - A submersible pump or the intake line of a surface pump or bailer shall be placed just below the water surface when removing the stagnant water and lowered as the water level drops. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. Once this is accomplished, a bailer or other approved device may be used to collect the sample for analysis.

   - The intake line of the sampling pump (or the submersible pump itself) shall be placed near the bottom of the screened section, and approximately one casing volume of water shall be pumped from the well at a low purge rate, equal to the well's recovery rate (low flow sampling).

Stratification of contaminants may exist in the aquifer. Concentration gradients as a result of mixing and dispersion processes, layers of variable permeability, and the presence of separate-phase product (i.e.,

floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column as it naturally occurs at that point, thus the result is the collection of a non-representative sample.

5.2 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform with the guidelines expressed in SOP SA-6.1.

The following equipment shall be on hand when sampling groundwater wells (reference SOPs SA-6.1 and SA-7.1):

- Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, appropriate sampling containers and filler, ice, labels and chain-of-custody documents.
- Field tools and instrumentation - Multi-parameters water quality meter capable of measuring ORP, pH, temperature, DO, specific conductance, turbidity and salinity or individual meters (as applicable), pH paper, camera and film (if appropriate), appropriate keys (for locked wells), engineer's rule, water level indicator.
- Pumps
  - Shallow-well pumps: Centrifugal, bladder, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing) where applicable.
  - Deep-well pumps: Submersible pump and electrical power-generating unit, or bladder pumps where applicable.
- Other sampling equipment - Bailers and inert line with tripod-pulley assembly (if necessary).
- Pails - Plastic, graduated.
- Decontamination solutions - Deionized water, potable water, laboratory detergents, 10% nitric acid solution (as required), and analytical-grade solvent (e.g., pesticide-grade isopropanol), as required.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior to use, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection.

5.3 Calculations of Well Volume

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to know the volume of standing water in the well pipe. This volume can be easily calculated by the following method. Calculations shall be entered in the site logbook or field notebook or on a sample log sheet form (see SOP SA-6.3):

- Obtain all available information on well construction (location, casing, screens, etc.).
- Determine well or casing diameter.
- Measure and record static water level (depth below ground level or top of casing reference point).

- Determine depth of well by sounding using a clean, decontaminated, weighted tape measure.
- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).
- Calculate one static well volume in gallons $V = (0.163)(T)(r^2)1$

where: V = Static volume of well in gallons.
T= Thickness of water table in the well measured in feet (i.e., linear feet of static water).
r = Inside radius of well casing in inches.
0.163 = A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.

- Per evacuation volumes discussed above, determine the minimum amount to be evacuated before sampling.

5.4 Evacuation of Static Water (Purging)

5.4.1 General

The amount of purging a well shall receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of wat r resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately the well can be pumped until the parameters such as temperature, specific conductance, pH, and turbidity (as applicable), have stabilized. Onsite measurements of these parameters shall be recorded in the site logbook, field notebook, or on standardized data sheets.

5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment A provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Bailers are inexpensive, and can be dedicated and hung in a well to reduce the chances of cross-contamination.

- There is minimal outgassing of volatile organics while the sample is in the bailer.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.

Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, and peristaltic pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause significant loss of dissolved gases and volatile organics.

Air-Lift Samplers

This group of pump samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Air (or gas)-lift samplers are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation, or loss of volatile organics.

Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch-diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- They may have low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components can be difficult and time-consuming.

5.5 Onsite Water Quality Testing

This section describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific Conductance
- Temperature
- Dissolved Oxygen (DO)
- Oxidation Reduction Potential (ORP)
- Certain Dissolved Constituents Using Specific Ion Elements
- Turbidity
- Salinity

This section is applicable for use in an onsite groundwater quality monitoring program to be conducted at a hazardous or nonhazardous site. The procedures and equipment described are applicabl to groundwater samples and are not, in general, subject to solution interferences from color, turbidity, and colloidal material or suspended matter.

This section provides general information for measuring the parameters listed above with instruments and techniques in common use. Since instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use.

5.5.1 Measurement of pH

5.5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken.

Two methods are given for pH measurement: the pH meter and pH indicator paper. The indicator paper is used when only a rough estimate of the pH is required, and the pH meter when a more accurate measurement is needed. The response of a pH meter can be affected to a slight degree by high levels of colloidal or suspended solids, but the effect is usually small and generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

5.5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity of the solution created by the addition of the water sample reacting with the indicator compound on the paper. Various types of pH papers are available, including litmus (for general acidity or alkalinity determination) and specific pH range hydrion paper.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to (in this instance, hydrogen) ion concentration across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to the ion concentration is generated and measured.

5.5.1.3 Equipment

The following equipment is needed for taking pH measurements:

- Stand-alone portable pH meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber (e.g., YSI 610).
- Combination electrode with polymer body to fit the above meter (alternately a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs).
- Buffer solutions, as specified by the manufacturer.
- pH indicator paper, to cover the pH range 2 through 12.
- Manufacturer's operation manual.

5.5.1.4 Measurement Techniques for Field Determination of pH

pH Meter

The following procedure is used for measuring pH with a pH meter (meter standardization is according to manufacturer's instructions):

- Inspect the instrument and batteries prior to initiation of the field effort.
- Check the integrity of the buffer solutions used for field calibration. Buffer solutions need to be changed often as a result of degradation upon exposure to the atmosphere.
- If applicable, make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).
- Calibrate on a daily use basis (or as recommended by manufacturer) following manufacturer's instructions. Record calibration data on an equipment calibration log sheet.
- Immerse the electrode(s) in the sample, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a physical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.
- Read and record the pH of the sample. pH shall be recorded to the nearest 0.01 pH unit. Also record the sample temperature.
- Rinse the electrode(s) with deionized water.
- Store the electrode(s) in an appropriate manner when not in use.

Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted.

pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper and proceed with successively narrower range paper until the sample pH is adequately determined.

5.5.2 Measurement of Specific Conductance

5.5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance.

5.5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, while the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases and salts (such as hydrochloric acid, sodium carbonate, or sodium chloride, respectively) are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not dissociate in aqueous solution, conduct a current very poorly, if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

5.5.2.3 Equipment

The following equipment is needed for taking specific conductance (SC) measurements:

- Stand alone portable conductivity meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber (e.g., YSI 610).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

A variety of conductivity meters are available which may also be used to monitor salinity and temperature. Probe types and cable lengths vary, so equipment must be obtained to meet the specific requirement of the sampling program.

5.5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate instrument before going into the field.
- Calibrate on a daily use basis (or as recommended by manufacturer), according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet. Potassium chloride solutions with a SC closest to the values expected in the field shall be used for calibration. Attachment B provides guidance in this regard.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the electrode in the sample and measure the conductivity. Adjust the temperature setting to the sample temperature (if applicable).
- Read and record the results in a field logbook or sample log sheet.
- Rinse the electrode with deionized water.

If the specific conductance measurements become erratic, recalibrate the instrument and see the manufacturer's instructions for details.

5.5.3 Measurement of Temperature

5.5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in-situ, or as quickly as possible in the field. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

5.5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury filled or dial-type thermometers. In addition, various meters such as specific conductance or dissolved oxygen meters, which have

temperature measurement capabilities, may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

5.5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used to determine the temperature for a water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of cross-contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.
- Record values in a field logbook or sample log sheet.

If a temperature meter or probe is used, the instrument shall be calibrated according to manufacturer's recommendations.

5.5.4 Measurement of Dissolved Oxygen

5.5.4.1 General

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ, since concentration may show a large change in a short time if the sample is not adequately preserved.

The monitoring method discussed herein is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible, and is not susceptible to interference caused by color, turbidity, colloidal material or suspended matter.

5.5.4.2 Principles of Equipment Operation

Dissolved oxygen probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH^-) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode.

Since the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, while leaving the surface of the solution undisturbed.

Dissolved oxygen probes are relatively unaffected by interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide, which are not easily depolarized from the indicating electrode. If a gaseous interference is suspected, it shall be noted in the field log book and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer.

5.5.4.3 Equipment

The following equipment is needed to measure dissolved oxygen concentration:

- Stand alone portable dissolved oxygen meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber (e.g., YSI 610).
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.

5.5.4.4 Measurement Techniques for Dissolved Oxygen Determination

Probes differ as to specifics of use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure the dissolved oxygen concentration:

- The equipment shall be calibrated and have its batteries checked before going to the field.
- The probe shall be conditioned in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
- The instrument shall be calibrated in the field according to manufacturer's recommendations or in a freshly air-saturated water sample of known temperature. Dissolved oxygen values for air-saturated water can be determined by consulting a table listing oxygen solubilities as a function of temperature and salinity (see Attachment C).
- Record all pertinent information on an equipment calibration sheet.
- Rinse the probe with deionized water.
- Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane by stirring the sample. Probes without stirrers placed in wells can be moved up and down.
- Record the dissolved oxygen content and temperature of the sample in a field logbook or sample log sheet.
- Rinse the probe with deionized water.
- Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable, since sample handling is not involved. This however, may not always be practical. Be sure to record whether the liquid was analyzed in-situ, or if a sample was taken.

Special care shall be taken during sample collection to avoid turbulence which can lead to increased oxygen solubilization and positive test interferences.

5.5.5 Measurement of Oxidation-Reduction Potential

5.5.5.1 General

The oxidation-reduction potential (ORP) provides a measure of the tendency of organic or inorganic compounds to exist in an oxidized state. The ORP parameter therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of oxidized to reduced species in the sample.

5.5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and is dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as dissolved oxygen, may be correlated with ORP to provide a knowledge of the quality of the solution, water, or wastewater.

5.5.5.3 Equipment

The following equipment is needed for measuring the oxidation-reduction potential of a solution:

- Portable pH meter or equivalent, with a millivolt scale.
- Platinum electrode to fit above pH meter.
- Reference electrode such as a calomel, silver-silver chloride, or equivalent.
- Reference solution as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring oxidation-reduction potential:

- The equipment shall be calibrated and have its batteries checked before going to the field.
- Check that the platinum probe is clean and that the platinum bond or tip is unoxidized. If dirty, polish with emery paper or, if necessary, clean the electrode using aqua regia, nitric acid, or chromic acid, in accordance with manufacturer's instructions.
- Thoroughly rinse the electrode with deionized water.
- Verify the sensitivity of the electrodes by noting the change in millivolt reading when the pH of the test solution is altered. The ORP will increase when the pH of the test solution decreases, and the ORP

will decrease if the test solution pH is increased. Place the sample in a clean container and agitate the sample. Insert the electrodes and note the ORP drops sharply when the caustic is added (i.e., pH is raised) thus indicating the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions. If the ORP does not respond as above when the caustic is added, the electrodes shall be cleaned and the above procedure repeated.

- After the assembly has been checked for sensitivity, wash the electrodes with three changes of water or by means of a flowing stream of deionized water from a wash bottle. Place the sample in a clean container and insert the electrodes. Set temperature compensator throughout the measurement period. Read the millivolt potential of the solution, allowing sufficient time for the system to stabilize and reach temperature equilibrium. Measure successive portions of the sample until readings on two successive portions differ by no more than 10 mV. A system that is very slow to stabilize properly will not yield a meaningful ORP. Record all results in a field logbook or sample logsheet, including ORP (to nearest 10 mV), sample temperature and pH at the time of measurement.

5.5.6 Measurement of Turbidity

5.5.6.1 General

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample. Turbidity in water is caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and microscopic organisms, including plankton.

It is important to obtain a turbidity reading immediately after taking a sample, since irreversible changes in turbidity may occur if the sample is stored too long.

5.5.6.2 Principles of Equipment Operation

Turbidity is measured by the Nephelometric Method. This method is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the scattered light intensity, the higher the turbidity.

Formazin polymer is used as the reference turbidity standard suspension because of its ease of preparation combined with a higher reproducibility of its light-scattering properties than clay or turbid natural water. The turbidity of a specified concentration of formazin suspension is defined as 40 nephelometric units. This same suspension has an approximate turbidity of 40 Jackson units when measured on the candle turbidmeter. Therefore, nephelometric turbidity units (NTU) based on the formazin preparation will approximate units derived from the candle turbidimeter but will not be identical to them.

5.5.6.3 Equipment

The following equipment is needed for turbidity measurement:

- Stand alone portable turbidity meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber (e.g., YSI 61).

- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.6.4 Measurement Techniques for Turbidity

The steps involved in taking turbidity measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate instrument before going into the field.
- Check the expiration date (etc.) of the solutions used for field calibration.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the probe in the sample and measure the turbidity. The reading must be taken immediately as suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.
- Read and record the results in a field logbook or sample log sheet. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.
- Rinse the electrode with deionized water.

5.5.7 Measurement of Salinity

5.5.7.1 General

Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved salts in a given mass of solution. Note: Most field meters determined salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or % (e.g., 35 ppt will equal 3.5%).

5.5.7.2 Principles of Equipment Operation

Salinity is determined automatically from the meter's conductivity and temperature readings according to algorithms (found in *Standard methods for the Examination of Water and Wastewater*). Depending on the meter, the results are displayed in either ppt or %. The salinity measurements are carried out in reference to the conductivity of standard seawater (*corrected to S = 35*).

5.5.7.3 Equipment

The following equipment is needed for Salinity measurements:

- Multi-parameter water quality meter capable of measuring conductive, temperature and converting them to salinity (e.g., Horiba U-10 or YSI 610).
- Calibration Solution, as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.7.4 Measurement Techniques for Salinity

The steps involved in taking Salinity measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate before going into the field.
- Check the expiration date (etc.) of the solutions used for field calibration.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.
- Rinse the cell with the sample to be tested.
- Immerse the probes in the sample and measure the salinity. Read and record the results in a field logbook or sample log sheet.
- Rinse the probes with deionized water.

5.6 Sampling

5.6.1 Sampling Plan

The sampling approach consisting of the following, shall be developed as part of the project plan documents which are approved prior to beginning work in the field:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).
- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.
- Sample preservation requirements.
- Work schedule.
- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

5.6.2 Sampling Methods

The collection of a groundwater sample consists of the following steps:

1. The site Health & Safety Officer (or designee) will first open the well cap and use volatile organic detection equipment (PID or FID) on the escaping gases at the well head to determine the need for respiratory protection.

2. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data on a groundwater sampling log sheet (see SOP SA-6.3); then calculate the fluid volume in the well pipe (as previously described in this SOP).

3. Calculate well volume to be removed as stated in Section 5.3.

4. Select the appropriate purging equipment (see Attachment A). If an electric submersible pump with packer is chosen, go to Step 10.

5. Lower the purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner (as applicable). Lower the purging device, as required, to maintain submergence.

6. Measure the rate of discharge frequently. A graduated bucket and stopwatch are most commonly used; other techniques include use of pipe trajectory methods, weir boxes or flow meters.

7. Observe the peristaltic pump intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics.

8. Purge a minimum of three to five casing volumes before sampling. In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Purged water shall be collected in a designated container and disposed in an acceptable manner.

9. If sampling using a pump, lower the pump intake to midscreen (or the middle of the open section in uncased wells) and collect the sample. If sampling with a bailer, lower the bailer to just below the water surface.

10. (For pump and packer assembly only). Lower the assembly into the well so that the packer is positioned just above the screen or open section. Inflate the packer. Purge a volume equal to at least twice the screened interval (or unscreened open section volume below the packer) before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.

11. In the event that recovery time of the well is very slow (e.g., 24 hours or greater), sample collection can be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record this occurrence in the site logbook.

12. Fill sample containers (preserve and label as described in SOP SA-6.1).

13. Replace the well cap and lock as appropriate. Make sure the well is readily identifiable as the source of the samples.

14. Process sample containers as described in SOP SA-6.1.

15. Decontaminate equipment as described in SOP SA-7.1.

5.7 Low Flow Purging and Sampling

5.7.1 Scope & Application

Low flow purging and sampling techniques are sometimes required for groundwater sampling activities. The purpose of low flow purging and sampling is to collect groundwater samples that contain "representative" amounts of mobile organic and inorganic constituents in the vicinity of the selected open well interval, at near natural flow conditions. The minimum stress procedure emphasizes negligible water level drawdown and low pumping rates in order to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 2 inches or more and a saturated screen, or open interval, length of ten feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semi-volatile organic compounds, pesticides, PCBs, metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This procedure is not designed to collect non-aqueous phase liquids samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs), using the low flow pumps.

The procedure is flexible for various well construction types and groundwater yields. The goal of the procedure is to obtain a turbidity level of less than 5 NTU and to achieve a water level drawdown of less than 0.3 feet during purging and sampling. If these goals cannot be achieved, sample collection can take place provided the remaining criteria in this procedure are met.

5.7.2 Equipment

The following equipment is required (as applicable) for low flow purging and sampling:

- Adjustable rate, submersible pump (e.g., centrifugal or bladder pump constructed of stainless steel or Teflon).
- Disposable clear plastic bottom filling bailers may be used to check for and obtain samples of LNAPLs or DNAPLs.
- Tubing - Teflon, Teflon-lined polyethylene, polyethylene, PVC, Tygon, stainless steel tubing can be used to collect samples for analysis, depending on the analyses to be performed and regulatory requirements.
- Water level measuring device, 0.01 foot accuracy, (electronic devices are preferred for tracking water level drawdown during all pumping operations).
- Flow measurement supplies.
- Interface probe, if needed.

- Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.
- Indicator parameter monitoring instruments - pH, turbidity, specific conductance, and temperature. Use of a flow-through cell is recommended. Optional Indicators - ORP and dissolved oxygen, flow-through cell is required. Standards to perform field calibration of instruments.
- Decontamination supplies.
- Logbook(s), and other forms (e.g., well purging forms).
- Sample Bottles.
- Sample preservation supplies (as required by the analytical methods).
- Sample tags and/or labels.
- Well construction data, location map, field data from last sampling event.
- Field Sampling Plan.
- PID or FID instrument for measuring VOCs (volatile organic compounds).

5.7.3 Purging and Sampling Procedure

Use a submersible pump to purge and sample monitoring wells which have a 2.0 inch or greater well casing diameter.

Measure and record the water level immediately prior to placing the pump in the well.

Lower pump, safety cable, tubing and electrical lines slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of sediment that may be present in the bottom of th well. Collection of turbidity-free water samples may be difficult if there is three feet or less of standing water in the well.

When starting the pump, slowly increase the pump speed until a discharge occurs. Check water level. Adjust pump speed to maintain little or no water level drawdown. The target drawdown should be less than 0.3 feet and it should stabilize. If the target of less than 0.3 feet cannot be achieved or maintained, the sampling is acceptable if remaining criteria in the procedure are met. Subsequent sampling rounds will probably have intake settings and extraction rates that are comparable to those used in the initial sampling rounds.

Monitor water level and pumping rate every five to ten minutes (or as appropriate) during purging. Record pumping rate adjustments and depths to water. Pumping rates should, as needed, be reduced to the minimum capabilities of the pump (e.g., 0.1-0.2 l/min) to ensure stabilization of indicator parameters. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During initial pump start-up, drawdown may exceed the 0.3 feet target and then recover as pump flow adjustments are made (minimum purge volume calculations should utilize stabilized drawdown values, not the initial drawdown). If the recharge rate of the well is less than minimum capability of the pump do not

allow the water level to fall to the intake level (if the static water level is above the screen, avoid lowering the water level into the screen). Shut off the pump if either of the above is about to occur and allow the water level to recover. Repeat the process until field indicator parameters stabilize and the minimum purge volume is removed. The minimum purge volume with negligible drawdown (0.3 feet or less) is two saturated screen length volumes. In situations where the drawdown is greater than 0.3 feet and has stabilized, the minimum purge volume is two times the saturated screen volume plus the stabilized drawdown volume. After the minimum purge volume is attained (and field parameters have stabilized) begin sampling. For low yields wells, commence sampling as soon as the well has recovered sufficiently to collect the appropriate volume for all anticipated samples.

During well purging, monitor field indicator parameters (turbidity, temperature, specific conductance, pH, etc.) every five to ten minutes (or as appropriate). Purging is complete and sampling may begin when all field indicator parameters have stabilized (variations in values are within ten percent of each other, pH +/- 0.2 units, for three consecutive readings taken at five to ten minute intervals). If the parameters have stabilized, but turbidity remains above 5 NTU goal, decrease pump flow rate, and continue measurement of parameters every five to ten minutes. If pumping rate cannot be decreased any further and stabilized turbidity values remain above 5 NTU goal record this information. Measurements of field parameters should be obtained (as per Section 5.5) and recorded.

VOC samples are preferably collected first, directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, use one of the following procedures to collect VOC samples: (1) Collect the non-VOCs samples first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample and record the new flow rate; (2) reduce the diameter of the existing tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel), or clamp which should reduce the flow rate by constricting the end of the tubing; (3) insert a narrow diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, collect sample from the narrow diameter tubing.

Prepare samples for shipping as per SOP SA-6.1.

6.0 REFERENCES

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ATTACHMENT A

PURGING EQUIPMENT SELECTION

Diameter Casing		Bailer	Peristaltic Pump	Vacuum Pump	Air-lift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-Inch	Water level <25 feet		X	X	X	X			
	Water Level >25 feet				X				
2-Inch	Water level <25 feet	X	X	X	X	X	X		
	Water Level >25 feet	X			X		X		
4-Inch	Water level <25 feet	X	X	X	X	X	X	X	X
	Water Level >25 feet	X			X		X	X	X
6-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X
8-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 2

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	Dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 feet of submergence	$220-350	Requires compressed gas; custom sizes and materials available; acts as piezometer.
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	Portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	$500-600	AC/DC; variable speed control available; other models may have different flow rates.
ECO Pump Corp.	SAMPLifier	Portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	$400-700	AC, DC, or gasoline-driven motors available; must be primed.
Geltek Corp.	Bailer 219-4	Portable; grab (positive displacement)	1.66/38	Teflon®	No limit	1,075 mL	$120-135	Other sizes available.
GeoEngineering, Inc.	GEO-MONITOR	Dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	Probably 0-150	Approximately 1 liter for each 10 feet of submergence	$185	Acts as piezometer; requires compressed gas.
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	Portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2,800 mL/min	$1,500-3,000	Requires compressed gas; other models available; AC, DC, manual operation possible.
IEA	Syringe Sampler	Portable, grab (positive displacement)	1.75/43	SS, Teflon®	No limit	850 mL sample volume	$1,100	Requires vacuum and/or pressure from hand pump.
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	Portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Detrin®, acetal	0-150	0-7,500 mL/min	$990	Requires compressed gas (40 psi minimum).
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	Portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4,500 mL/min	$3,500	DC operated.
Leonard Mold and Die Works, Inc.	GeoFilter Small Diameter Well Pump (#0500)	Portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3,500 mL/min	$1,400-1,500	Requires compressed gas (55 psi minimum); pneumatic or AC/DC control module.
Oil Recovery Systems, Inc.	Surface Sampler	Portable; grab (positive displacement)	1.75/12	acrylic, Detrin®	No limit	Approximately 250 mL	$125-160	Other materials and models available; for measuring thickness of "floating" contaminants.
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	Dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2,000 mL/min	$300-400	Requires compressed gas; piezometric level indicator; other materials available.

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 3

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
Randolph Austin Co.	Model 500 Van-Flow Pump	Portable; peristaltic (suction)	<0.5/NA	(Not submersible) Rubber, Tygon®, or Neoprene®	0-30	See comments	$1,200-1,300	Flow rate dependent on motor and tubing selected; AC operated; other models available.
Robert Bennett Co.	Model 180	Portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin® PP, Viton®, acrylic, PE	0-500	0-1,800 mL/min	$2,600-2,700	Requires compressed gas; water level indicator and flow meter; custom models available.
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	Portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1,100	250 mL/flushing cycle	$250-350	Requires compressed gas; SS available; piezometer model available; dedicated model available.
Solinst Canada Ltd.	5W Water Sampler	Portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	$1,300-1,800	Requires compressed gas; custom models available.
TIMCO Mfg. Co., Inc.	Std. Bailer	Portable; grab (positive displacement)	1.66/Custom	PVC, PP	No limit	250 mL/ft of bailer	$20-60	Other sizes, materials, models available; optional bottom-emptying device available; no solvents used.
TIMCO	Air or Gas Lift Sampler	Portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	$100-200	Requires compressed gas; other sizes, materials, models available; no solvents used.
Tole Devices Co.	Sampling Pump	Portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4,000 mL/min	$800-1,000	Compressed gas required; DC control module; custom built.

Construction Material Abbreviations:

PE	Polyethylene
PP	Polypropylene
PVC	Polyvinyl chloride
SS	Stainless steel
PC	Polycarbonate
EPDM	Ethylene-propylene diene (synthetic rubber)

Other Abbreviations:

NA	Not applicable
AC	Alternating current
DC	Direct current

NOTE: Other manufacturers market pumping devices which could be used for groundwater sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983.

ATTACHMENT B

SPECIFIC CONDUCTANCE OF 1 MOLAR KCl AT VARIOUS TEMPERATURES[1]

Temperature (°C)	Specific Conductance (umhos/cm)
15	1,147
16	1,173
17	1,199
18	1,225
19	1,251
20	1,278
21	1,305
22	1,332
23	1,359
24	1,368
25	1,413
26	1,441
27	1,468
28	1,496
29	1,524
30	1,552

[1] Data derived from the International Critical Tables 1-3-8.

ATTACHMENT C

VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY

Temperature (°C)	Dissolved Oxygen (mg/L)					
	Chloride Concentration in Water					Difference/ 100 mg Chloride
	0	5,000	10,000	15,000	20,000	
0	14.6	13.8	13.0	12.1	11.3	0.017
1	14.2	13.4	12.6	11.8	11.0	0.016
2	13.8	13.1	12.3	11.5	10.8	0.015
3	13.5	12.7	12.0	11.2	10.5	0.015
4	13.1	12.4	11.7	11.0	10.3	0.014
5	12.8	12.1	11.4	10.7	10.0	0.014
6	12.5	11.8	11.1	10.5	9.8	0.014
7	12.2	11.5	10.9	10.2	9.6	0.013
8	11.9	11.2	10.6	10.0	9.4	0.013
9	11.6	11.0	10.4	9.8	9.2	0.012
10	11.3	10.7	10.1	9.6	9.0	0.012
11	11.1	10.5	9.9	9.4	8.8	0.011
12	10.8	10.3	9.7	9.2	8.6	0.011
13	10.6	10.1	9.5	9.0	8.5	0.011
14	10.4	9.9	9.3	8.8	8.3	0.010
15	10.2	9.7	9.1	8.6	8.1	0.010
16	10.0	9.5	9.0	8.5	8.0	0.010
17	9.7	9.3	8.8	8.3	7.8	0.010
18	9.5	9.1	8.6	8.2	7.7	0.009
19	9.4	8.9	8.5	8.0	7.6	0.009
20	9.2	8.7	8.3	7.9	7.4	0.009
21	9.0	8.6	8.1	7.7	7.3	0.009
22	8.8	8.4	8.0	7.6	7.1	0.008
23	8.7	8.3	7.9	7.4	7.0	0.008
24	8.5	8.1	7.7	7.3	6.9	0.008
25	8.4	8.0	7.6	7.2	6.7	0.008

ATTACHMENT C
VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY
PAGE TWO

Temperature (°C)	Dissolved Oxygen (mg/L)					
	Chloride Concentration in Water					Difference/ 100 mg Chloride
	0	5,000	10,000	15,000	20,000	
26	8.2	7.8	7.4	7.0	6.6	0.008
27	8.1	7.7	7.3	6.9	6.5	0.008
28	7.9	7.5	7.1	6.8	6.4	0.008
29	7.8	7.4	7.0	6.6	6.3	0.008
30	7.6	7.3	6.9	6.5	6.1	0.008
31	7.5					
32	7.4					
33	7.3					
34	7.2					
35	7.1					
36	7.0					
37	6.9					
38	6.8					
39	6.7					
40	6.6					
41	6.5					
42	6.4					
43	6.3					
44	6.2					
45	6.1					
46	6.0					
47	5.9					
48	5.8					
49	5.7					
50	5.6					

Note: In a chloride solution, conductivity can be roughly related to chloride concentration (and therefore, used to correct measured D.O. concentration) using Attachment B.

TETRA TECH NUS, INC.	STANDARD OPERATING PROCEDURES	Number SA-6.1	Page 1 of 24
		Effective Date 03/00	Revision 1
		Applicability Tetra Tech NUS, Inc.	
		Prepared Earth Sciences Department	
Subject NON-RADIOLOGICAL SAMPLE HANDLING		Approved D. Senovich	

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide information on sample preservation, packaging, and shipping procedures to be used in handling environmental samples submitted for chemical constituent, biological, or geotechnical analysis. Sample chain-of-custody procedures and other aspects of field documentation are addressed in SOP SA-6.3. Sample identification is addressed in SOP CT-04.

2.0 SCOPE

This procedure:

- Describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped off site for chemical analysis.

- Provides instruction for sample packaging and shipping in accordance with current U.S. Department of Transportation (DOT) and International Air Transportation Association (IATA) regulations. IATA regulates transportation of hazardous materials by air (which is the mode of transportation used for shipping nearly all samples derived during TtNUS projects).

3.0 GLOSSARY

Hazardous Material - A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated. Under 49 CFR, the term includes hazardous substances, hazardous wastes, marine pollutants, and elevated temperature materials, as well as materials designated as hazardous under the provisions of §172.101 and §172.102 and materials that meet the defining criteria for hazard classes and divisions in Part 173. With slight modifications, IATA has adopted DOT "hazardous materials" as IATA "Dangerous Goods."

Hazardous Waste - Any substance listed in 40 CFR, Subpart D (ɣ261.30 et seq.), or otherwise characterized as ignitable, corrosive, reactive, or toxic (as defined by Toxicity Characteristic Leaching Procedure, TCLP, analysis) as specified under 40 CFR, Subpart C (ɣ261.20 et seq.), that would be subject to manifest requirements specified in 40 CFR 262. Such substances are defined and regulated by EPA.

Marking - A descriptive name, identification number, instructions, cautions, weight, specification or UN marks, or combination thereof required on outer packaging of hazardous materials.

n.o.i - Not otherwise indicated (may be used interchangeably with n.o.s.).

n.o.s. - Not otherwise specified.

ORM - Other regulated material (see DOT 49 CFR 173.144).

Packaging - A receptacle and any other components or materials necessary for compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, and multi-unit tank-car tanks to perform a containment function in conformance with the minimum packaging requirements of 49 CFR 173.24(a) & (b).

Placard - Color-coded, pictorial sign which depicts the hazard class symbol and name and which is placed on the side of a vehicle transporting certain hazardous materials.

Common Preservatives:

- Hydrochloric Acid - HCl
- Sulfuric Acid - H_2SO_4
- Nitric Acid - HNO_3
- Sodium Hydroxide - NaOH

Other Preservatives

- Zinc Acetate
- Sodium Thiosulfate - $Na_2S_2O_3$

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing 1 gram-atom of replaceable hydrogen or its equivalent.

Reportable Quantity (RQ) - For the purposes of this SOP, means the quantity specified in column 3 of the Appendix to DOT 49 CFR §172.101 for any material identified in column 1 of the appendix. A spill greater than the amount specified must be reported to the National Response Center.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the location and time of collection.

4.0 RESPONSIBILITIES

Field Operations Leader - Directly responsible for the bottling, preservation, labeling, packaging, shipping, and custody of samples up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record (per SOP SA-6.3), implementing the packaging and shipping requirements, and maintaining custody of samples until they are relinquished to another custodian or to the shipper.

5.0 PROCEDURES

Sample identification, labeling, documentation, and chain-of-custody are addressed by SOP SA-6.3.

5.1 Sample Containers

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, whereas many organic chemicals may dissolve various types of plastic containers. Attachments A and B show proper containers (as well as other information) per 40 CFR 136. In general, the sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample warms during transport. However, for collection of volatile organic compounds, head space shall be omitted. The analytical laboratory will generally provide certified-clean containers for samples to be analyzed for chemical constituents. Shelby tubes or other sample containers are generally provided by the driller for samples requiring geotechnical analysis. Sufficient lead time shall be allowed for a delivery of sample container orders. Therefore, it is critical to use the correct container to maintain the integrity of the sample prior to analysis.

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded. Because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused

containers which appear contaminated upon receipt, or which are found to have loose caps or a missing Teflon liner (if required for the container), shall be discarded.

5.2 Sample Preservation

Many water and soil samples are unstable and therefore require preservation to prevent changes in either the concentration or the physical condition of the constituent(s) requiring analysis. Although complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological changes that inevitably take place after the sample is collected. Preservation techniques are usually limited to pH control, chemical addition(s), and refrigeration/ freezing (certain biological samples only).

5.2.1 Overview

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the field or be added in the field (in a clean environment). Only high purity reagents shall be used for preservation. In general, aqueous samples of low-concentration organics (or soil samples of low- or medium-concentration organics) are cooled to 4°C. Medium-concentration aqueous samples, high-hazard organic samples, and some gas samples are typically not preserved. Low-concentration aqueous samples for metals are acidified with HNO_3, whereas medium-concentration and high-hazard aqueous metal samples are not preserved. Low- or medium-concentration soil samples for metals are cooled to 4°C, whereas high-hazard samples are not cooled.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

5.2.2 Preparation and Addition of Reagents

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade or purer and shall be diluted to the required concentration with deionized water before field sampling commences. To avoid uncontrolled reactions, be sure to Add Acid to water (not vice versa). A dilutions guide is provided below.

Acid/Base	Dilution	Concentration	Estimated Amount Required for Preservation
Hydrochloric Acid (HCl)	1 part concentrated HCl: 1 part double-distilled, deionized water	6N	5-10 mL
Sulfuric Acid (H_2SO_4)	1 part concentrated H_2SO_4: 1 part double-distilled, deionized water	18N	2 - 5 mL
Nitric Acid (HNO_3)	Undiluted concentrated HNO_3	16N	2 - 5 mL
Sodium Hydroxide (NaOH)	400 grams solid NaOH dissolved in 870 mL double-distilled, deionized water; yields 1 liter of solution	10N	2 mL

The amounts required for preservation shown in the above table assumes proper preparation of the preservative and addition of the preservative to one liter of aqueous sample. This assumes that the sample is initially at pH 7, is poorly buffered, and does not contain particulate matter; as these conditions vary, more preservative may be required. Consequently, the final sample pH must be checked using narrow-range pH paper, as described in the generalized procedure detailed below:

- Pour off 5-10 mL of sample into a dedicated, clean container. Use some of this sample to check the initial sample pH using wide range (0-14) pH paper. Never dip the pH paper into the sample; always apply a drop of sample to the pH paper using a clean stirring rod or pipette.

- Add about one-half of the estimated preservative required to the original sample bottle. Cap and invert gently several times to mix. Check pH (as described above) using medium range pH paper (pH 0-6 or pH 7.5-14, as applicable).

- Cap sample bottle and seal securely.

Additional considerations are discussed below:

- To test if ascorbic acid must be used to remove oxidizing agents present in the sample before it can be properly preserved, place a drop of sample on KI-starch paper. A blue color indicates the need for ascorbic acid addition.

  If required, add a few crystals of ascorbic acid to the sample and retest with the KI-starch paper. Repeat until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 grams of ascorbic acid per each liter of sample volume.

  Continue with proper base preservation of the sample as described above.

- Samples for sulfide analysis must be treated by the addition of 4 drops (0.2 mL) of 2N zinc acetate solution per 100 ml of sample.

  The 2N zinc acetate solution is made by dissolving 220 grams of zinc acetate in 870 mL of double-distilled, deionized water to make 1 liter of solution.

  The sample pH is then raised to 9 using the NaOH preservative.

- Sodium thiosulfate must be added to remove residual chlorine from a sample. To test the sample for residual chlorine use a field test kit specially made for this purpose.

  If residual chlorine is present, add 0.08 grams of sodium thiosulfate per liter of sample to remove the residual chlorine.

  Continue with proper acidification of the sample as described above.

For biological samples, 10% buffered formalin or isopropanol may also be required for preservation. Questions regarding preservation requirements should be resolved through communication with the laboratory before sampling begins.

5.3 Field Filtration

At times, field-filtration may be required to provide for the analysis of dissolved chemical constituents. Field-filtration must be performed prior to the preservation of samples as described above. General procedures for field filtration are described below:

- The sample shall be filtered through a non-metallic, 0.45-micron membrane filter, immediately after collection. The filtration system shall consist of dedicated filter canister, dedicated tubing, and a peristaltic pump with pressure or vacuum pumping squeeze action (since the sample is filtered by mechanical peristalsis, the sample travels only through the tubing).

- To perform filtration, thread the tubing through the peristaltic pump head. Attach the filter canister to the discharge end of the silicon tubing (note flow direction arrow); attach the aqueous sample container to the intake end of the silicon tubing. Turn the peristaltic pump on and perform filtration. Run approximately 100 ml of sample through the filter prior to sample collection.

- Continue by preserving the filtrate (contained in the filter canister), as applicable and generally described above.

5.4 Sample Packaging and Shipping

Samples collected for shipment from a site shall be classified as either environmental or hazardous material samples. Samples from drums containing materials other than Investigative Derived Waste (IDW) and samples obtained from waste piles or bulk storage tanks are generally shipped as hazardous materials. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples (if there is any doubt, a sample shall be considered hazardous and shipped accordingly.)

- Protect the health and safety of transport and laboratory personnel receiving the samples (special precautions are used by the shipper and at laboratories when hazardous materials are received.)

Detailed procedures for packaging environmental and hazardous material samples are outlined in the remainder of this section.

5.4.1 Environmental Samples

Environmental samples are packaged as follows:

- Place properly identified sample container, with lid securely fastened, in a plastic bag (e.g. Ziploc baggie), and seal the bag.

- Place sample in a cooler constructed of sturdy material which has been lined with a large, plastic (e.g. "garbage" bag). Drain plugs on coolers must be taped shut.

- Pack with enough noncombustible, absorbent, cushioning materials such as vermiculite (shoulders of bottles must be iced if required) to minimize the possibility of the container breaking.

- If cooling is required (see Attachments A and B), double-bag ice in Ziploc baggies and place around sample container shoulders, and on top of absorbent packing material (minimum of 8 pounds of ice for a medium-size cooler).

- Seal (i.e., tape or tie top in knot) large liner bag.

- The original (top, signed copy) and extra carbonless copies of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the first cooler. The COC form should then state how many coolers are included with that shipment.

- Close and seal outside of cooler as described in SOP SA-6.3. Signed custody seals must be used.

Coolers must be marked as containing "Environmental Samples." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling is required; there are no DOT restrictions on mode of transportation.

5.4.2 Hazardous Material Samples

Samples not determined to be environmental samples, or samples known or expected to contain hazardous materials, must be considered hazardous material samples and transported according to the requirements listed below.

NOTE: Packaging and shipping of hazardous materials can only be performed by personnel who have participated in the TtNUS training course "Shipping Hazardous Materials" (or equivalent training approved by Health Sciences).

5.4.2.1 Known Substances

If the substance in the sample is known or can be identified, package, mark, label, and ship according to the specific instructions for that material (if it is listed) in the DOT Hazardous Materials Table (49 CFR 172.101) or the IATA List of Dangerous Goods Table (IATA Dangerous Goods Regulations). DOT Guide for shippers can be found in Attachment D of this document.

To determine the proper shipping name, use the following steps to help locate the shipping name on the Hazardous Materials Table, DOT 49 CFR 172.101.

1. Look first for the chemical or technical name of the material, for example, ethyl alcohol. Note that many chemicals have more than one technical name, for example, perchloroethylene (not listed in 172.101) is listed as tetrachloroethylene (listed 172.101). It may be useful to consult Health Sciences or a chemist for all possible technical names a material can have. If your material is not listed by its technical name, then . . .

2. Look for the chemical family name. For example, pentyl alcohol is not listed but the chemical family name is: alcohol, n.o.s. (not otherwise specified). If the chemical family name is not listed, then . . .

3. Look for a generic name based on end use. For example, Paint, n.o.s. If a generic name based on end use is not listed, then . . .

4. Look for a generic family name based on end use, for example, drugs, n.o.s. or cosmetics, n.o.s. Finally, if your material is not listed by a generic family name but you suspect or know the material is hazardous because it meets the definition of one or more hazardous classes, then . . .

5. You will have to use the general hazard class for a proper shipping name. For example, Flammable Liquid, n.o.s, or Oxidizer, n.o.s.

If you have any doubt regarding the proper shipping name, contact Health Sciences in Pittsburgh, Pennsylvania for assistance.

5.4.2.2 Unknown Substances

For samples of hazardous substances that are not listed on the Hazardous Materials Table, or are of unknown content, the shipper is required to:

1. Determine that the substance is not forbidden for shipment. Items forbidden include explosives (solid and liquid), substances liable to produce a dangerous evolution of heat or gas, and listed "unusual" compounds (which TtNUS fortunately does not typically handle). If the substance is in any way atypical of routine shipments, contact Health Sciences for further information on determining if the substance is forbidden.

2. Classify the substance by assessing whether it is anticipated to exhibit any unusual physical properties as defined by DOT (flammability, explosivity, etc.). If the substance has more than one hazard, follow the hazardous materials classification scheme identified in Attachment C of this SOP.

3. Use the generic or "n.o.s." proper shipping name that most accurately describes the article or substance. There are two types of general proper shipping names:

   - Generic, e.g., Alcohols, n.o.s. *
   - Hazard description, e.g., Flammable liquid, n.o.s.*

   Generic or n.o.s. proper shipping names marked with an "*" require the addition of the technical name in parenthesis () immediately following the proper shipping name. For example, most of our instrument calibration gases are not listed by name and must be declared under the most accurately descriptive name, which is "Compressed Gas, n.o.s. (Mixture Nitrogen and Oxygen)".

The correct shipping classification for an unknown sample is therefore selected through a process of elimination as described above (and detailed in 49 CFR 172.101(c)(11). By using the provisions in this paragraph, the proper shipping name and description will be determined. A step-by-step guide is provided by the DOT and can be found in Attachment D of this SOP. Again, if you have any doubt regarding the proper shipping name, contact Health Sciences for assistance.

5.4.3 Packaging and Shipping of Samples Classified as Flammable Liquid (or Solid)

5.4.3.1 Packaging

Applying the word "flammable" to a sample does not necessarily mean that it is in fact flammable. The word prescribes the class of packaging according to DOT regulations and classification schemes. The DOT defines flammable liquids as substances with a flash point less than 140°F (60°C). For shipping purposes, liquids with a flash point exceeding 95°F (35°C) need not be considered as flammable liquids if they are miscible solutions and have a water content of more than 90% by weight. For solutions classified as flammable liquids:

1. Containerize sample as required (see Attachments A and B). To prevent leakage, fill container no more than 90 percent full. Seal lid with teflon tape or wire.

2. Complete sample label and attach securely to sample container.

3. Seal container and place in 2-mil-thick (or thicker) polyethylene bag (e.g., Ziploc baggie), one sample per bag. Position sample identification label so that it can be read through bag. Seal bag.

4. For soil jars, place sealed bag inside metal can (available from laboratory or laboratory supplier) and cushion it with enough noncombustible, absorbent material (for example, vermiculite or diatomaceous earth) between the bottom and sides of the can and bag to prevent breakage and absorb leakage. Pack one bag per can. Use clips, tape, or other positive means to hold can lid securely, tightly and permanently. Mark can as indicated in Paragraph 1 of Section 5.3.4.2, below. Single 1-gallon bottles do not need to be placed in metal cans.

5. Place one or more metal cans (or a single 1-gallon bottle) into a strong outside container, such as a metal picnic cooler or a DOT-approved fiberboard box. Surround cans (or bottle) with noncombustible, absorbent cushioning materials for stability during transport. The absorbent material should be able to absorb the entire contents of the container. Mark container as indicated in Paragraph 2 below.

5.4.3.2 Marking/Labeling

1. Use abbreviations only where specified. Place the following information, either hand-printed or in label form, on the metal can (or 1-gallon bottle):

   - Laboratory name and address.
   - Proper shipping name from the hazardous materials table (DOT Regulation CFR 49 172.101). Example: "Flammable Liquid, n.o.s. (with the technical name in parentheses).

2. Determine packing group. The packing group must be included on the shipping papers in the description section. Packaging groups are classified as follows:

   Group I. Most Hazardous
   Group II. Medium Hazard
   Group III. Least Hazardous

   The packing group will be listed in the hazardous materials table, column 5.

3. Place the following information on outside shipping container per the instructions provided in the "Shipping Hazardous Materials" course:

   - Proper shipping name
   - UN or NA number
   - Proper label(s)
   - Addressee and sender

For flammable liquids, the following are the proper labels to be placed on the outside shipping container:

- DOT "Flammable liquid" label
- Package orientation label (arrows pointing upward) on at least two opposite sides of the package
- "Cargo Aircraft Only" label if shipping more than 30L of flammable liquids in the package.

5.4.3.3 Shipping Papers

Principally because of limitations in sample holding times, TtNUS almost exclusively uses air transportation to ship hazardous materials and other environmental samples. The "Dangerous Goods Airbill" is the shipping paper used to document the information associated with the shipment. As identified previously, only personnel who have participated in "Shipping Hazardous Materials" training (or equivalent course) are authorized to prepare hazardous materials for shipment - including preparation of associated shipping papers. Included in this training are instructions on what specific information is to be provided on the Airbill for hazardous materials typically shipped by TtNUS. Refer to the training course Student Manual or contact Health Sciences for this information.

The properly executed Chain-of-Custody Report must be included in the container. Use custody seals.

Using the Airbill of our common carrier (i.e., Federal Express) as an example, the following instructions apply to the information to be provided under "Transport Details", "Nature and Quantity of Dangerous Goods", and other associated fields.

a) Transport Details

- Select "Passenger and Cargo" or "Cargo Aircraft Only" (This is based on the type and quantity of dangerous goods you are shipping). X-out the non-applicable selection.
- Airport of Departure - Enter the full name of the airport or city of departure.
- Airport of Destination - Enter the full name of the airport or city of destination.

b) Shipment Type – Delete the option that does not apply (Non-Radioactive/Radioactive)

c) Nature and Quantity of Dangerous Goods

1. Dangerous Goods Identification

   - Proper Shipping Name - List the proper shipping name (this is the name as it appears on the List of Dangerous Goods Table and NOT the product or trade name), and if applicable, the technical name in parenthesis.
   - Class or Division - List the class or division number and, if applicable, compatibility group.
   - UN or ID No - List the UN or I.D. number, preceded with "UN" or "I.D." This selection may change when shipping in accordance with 49 CFR regulations that permit the shipment under NA (North American Continental Shipments) designations for certain substances.
   - Packing Group – List the appropriate packing group, if applicable. This is the level of anticipated hazard of the shipment. It does not apply for all shipments. When no information is available, leave the space blank.
   - Subsidiary Risk – List the class or division number of the subsidiary risk, if applicable. The subsidiary risk is any additional hazard beyond the most significant (or primary) hazard. This information is obtained from the List of Dangerous Goods Table.

2. Quantity and Type of Packaging – List the number of packages, the type of package, and the net quantity in each package. The type of packaging you are shipping the hazardous material in is presented first, followed by the amount (Kg, L, etc.). For example, "1 fiberboard box X 2 Kg". When no outer packaging is identified, the packaging selected must provide limited protection of the inner packaging by securing and cushioning during shipment. NOTE: Always use the package that the hazardous material was shipped to the site in. If it is not available, contact the Health Sciences Department in Pittsburgh for further instruction.

3. Packing Instructions – Enter the Packing Instruction number. These instructions are provided in Section 5 of the IATA Dangerous Goods Regulations. They provide the exact type of packaging required by the industry for various hazard classes. When no addition packaging considerations are given, the shipper may use their best judgment for the shipment of an identified substance and/or article.

4. Authorization – List the words " Limited Quantity," if applicable; list any special provision(s) or approval(s) if applicable. This section provides for exceptions to this transportation regulation and the conditions for those exceptions.

d) Additional handling Information - Enter any required special handling information.

e) Prepared for Air Transport according to: Check the ICAO/IATA box.

f) Emergency Telephone Number - Enter the 24-hour emergency contact number. This number is required of all US Origin or Destination Shipments. List the number for InfoTRAC (1-800-535-5053). InfoTRAC is a company retained by TtNUS to provide 24-Hour Emergency Hotline service for dangerous goods shipment. This company has MSDSs for the substances routinely shipped by TtNUS. They provide information to FedEx or any other emergency responders, should situations arise with one of our shipments. In addition, they have telephone numbers of certain Tetra Tech NUS Health Science Department personnel in the Pittsburgh Office in the event of an emergency.

g) Name/Title of the Signatory - Enter name and job title (Field Operations Leader, Geologist, Health & Safety Specialist, etc.)

h) Place and date - Enter the city and date of shipment

i) Signature - Sign the form (must be a complete signature). All alterations must be signed with the same signature used to sign the declaration.

5.4.3.4 Transportation

1. The majority of unknown hazardous substance samples will be classified as flammable liquids. The samples will be transported by rented or common carrier truck, railroad, or express overnight package services. Do not transport samples on any passenger-carrying air transport system, even if the system has cargo-only aircraft. DOT regulations permit regular airline cargo-only aircraft, but difficulties with most suggest avoiding them. Instead, ship by airline carriers that carry only cargo. If unsure of what mode of transportation to use, consult Health Sciences.1

2. For transport by government-owned vehicle, including aircraft, DOT regulations do not apply. However, procedures described above, with the exception of execution of the bill of lading with certification, shall still be followed.

3. Use the hazardous materials shipping check list (Attachment E) as a guidance to ensure that all sample-handling requirements are satisfied.

4. In some cases, various materials may react if they break during shipment. To determine if you are shipping such materials, refer to the DOT compatibility chart in Attachment F.

5.5 Shipment of Lithium Batteries

Monitoring well data are analyzed using either the Hermit SE 1000 or the Hermit SE 2000 environmental data logger. These instruments are typically powered by lithium batteries in sufficient quantity to make the unit subject to hazardous material shipping requirements. The DOT determined that lithium batteries are to be shipped using the following information:

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1 Note: If you are unsure as how to ship the sample (hazardous or environmental sample), contact Health Sciences so that a decision can be made as to the proper shipping practices. The DOT and IATA penalties for improper shipment of a hazardous material are stringent and may include a prison term for intentional violations.

- Product Designation
  - Hermit SE 1000
  - Hermit SE 2000

- Proper Shipping Name
  - Lithium batteries, contained in equipment, UN3091

- UN No - UN-3091

- Classification or Division
  - Class 9

Shipment of equipment containing lithium batteries must be accompanied by shipping papers completed as indicated in Attachment G. The instrument will be shipped by Federal Express as a Hazardous Material. Place the instrument in the same container in which it was received. This container or case is a DOT-approved shipping container. For Federal Express procedures to ship hazardous materials, call 1-800-238-5355, extension 922-1666. In most cases, the return shipping papers and DOT labels will be shipped to you from the company warehouse or the vendor. An example of the types of labels used for shipment and the wording are shown in Attachment G. These labels will be attached to the outside container and include all the information noted under Section 5.4.3.2. Instead of the Flammable Liquid information, however, the following will be presented with the following wording:

- Lithium Batteries Contained in Equipment
  - UN-3091

- DOT Miscellaneous Hazardous Materials (Class 9) label

- "Cargo Aircraft Only" label

6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater, 15th Edition. APHA, Washington, D.C.

International Air Transport Association (latest issue). Dangerous Goods Regulations, Montreal, Quebec, Canada.

U.S. Department of Transportation (latest issue). Hazardous Materials Regulations, 49 CFR 171-177.

U.S. EPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, U.S. EPA-EMSL, Cincinnati, Ohio.

ATTACHMENT A

GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS

Sample Type and Concentration		Container[1]	Sample Size	Preservation[2]	Holding Time[2]
WATER					
Organics (GC&GC/MS)	VOC Low	Borosilicate glass	2 x 40 mL	Cool to 4°C HCl to ≤ 2	14 days[9]
	Extractables (Low SVOCs and pesticide/PCBs)	Amber glass	2x2 L or 4x1 L	Cool to 4°C	7 days to extraction, 40 days after extraction
	Extractables (Medium SVOCs and pesticide/PCBs)	Amber glass	2x2 L or 4x1 L	None	7 days to extraction, 40 days after extraction
Inorganics	Metals Low	High-density polyethylene	1 L	HNO_3 to pH ≤2	6 months (Hg-28 days)
	Medium	Wide-mouth glass	16 oz	None	6 months
	Cyanide Low	High-density polyethylene	1 L	NaOH to pH>12	14 days
	Cyanide Medium	Wide-mouth glass	16 oz	None	14 days
Organic/ Inorganic	High Hazard	Wide-mouth glass	8 oz	None	14 days
SOIL					
Organics (GC&GC/MS)	VOC	Wide-mouth glass with teflon liner	2 x 4 oz.	Cool to 4°C	14 days
	Extractables (Low SVOCs and pesticides/PCBs)	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction, 40 days after extraction
	Extractables (Medium SVOCs and pesticides/PCBs)	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction, 40 days after extraction
Inorganics	Low/Medium	Wide-mouth glass	8 oz	Cool to 4°C	6 months (Hg - 28 days) Cyanide (14 days)
Organic/Inorganic	High Hazard	Wide-mouth glass	8 oz.	None	NA
Dioxin/Furan	All	Wide-mouth glass	4 oz.	None	7 days until extraction; 40 days after extraction
TCLP	All	Wide-mouth glass	8 oz.	None	7 days until preparation, analysis as per fraction
AIR					
Volatile Organics	Low/Medium	Charcoal tube – 7 cm long, 6 mm OD, 4 mm ID	100 L air	Cool to 4°C	5 days recommended

1 All glass containers should have Teflon cap liners or septa.
2 See Attachment E. Preservation and maximum holding time allowances per 40 CFR 136.

ATTACHMENT B

ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

Parameter Number/Name	Container[1]	Preservation[2][3]	Maximum Holding Time[4]
INORGANIC TESTS:			
Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia - Nitrogen	P, G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Biochemical Oxygen Demand (BOD)	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Chemical Oxygen Demand (COD)	P, G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Chloride	P, G	None required	28 days
Chlorine, Total Residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	P, G	Cool, 4°C, NaOH to pH 12; 0 6 g ascorbic acid[5]	14 days[6]
Fluoride	P	None required	28 days
Hardness	P, G	HNO_3 to pH 2, H_2SO_4 to pH 2	6 months
Total Kjeldahl and Organic Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Nitrate - Nitrogen	P, G	None required	48 hours
Nitrate-Nitrite - Nitrogen	P, G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Nitrite - Nitrogen	P, G	Cool, 4°C	48 hours
Oil & Grease	G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Total Organic Carbon (TOC)	P, G	Cool, 4°C, HCl or H_2SO_4 to pH 2	28 days
Orthophosphate	P, G	Filter immediately; Cool, 4°C	48 hours
Oxygen, Dissolved-Probe	G Bottle & top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle & top	Fix on site and store in dark	8 hours
Phenols	G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Phosphorus, Total	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Residue, Total	P, G	Cool, 4°C	7 days
Residue, Filterable (TDS)	P, G	Cool, 4°C	7 days
Residue, Nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, Settleable	P, G	Cool, 4°C	48 hours
Residue, Volatile (Ash Content)	P, G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific Conductance	P, G	Cool, 4°C	28 days
Sulfate	P, G	Cool, 4°C	28 days

ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES
PAGE TWO

Parameter Number/Name	Container[1]	Preservation[2][3]	Maximum Holding Time[4]
INORGANIC TESTS (Cont'd):			
Sulfide	P, G	Cool, 4°C; add zinc acetate plus sodium hydroxide to pH 9	7 days
Sulfite	P, G	None required	Analyze immediately
Turbidity	P, G	Cool, 4°C	48 hours
METALS:[7]			
Chromium VI (Hexachrome)	P, G	Cool, 4°C	24 hours
Mercury (Hg)	P, G	HNO_3 to pH 2	28 days
Metals, except Chromium VI and Mercury	P, G	HNO_3 to pH 2	6 months
ORGANIC TESTS:[8]			
Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C, 0 008% $Na_2S_2O_3$[5]	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C, 0 008% $Na_2S_2O_3$[5] HCl to pH 2 [9]	14 days
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool, 4°C, 0 008% $Na_2S_2O_3$[5] adjust pH to 4-5 [10]	14 days
Phenols[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
Benzidines[11],[12]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction[13]
Phthalate esters[11]	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitrosamines[11],[14]	G, Teflon-lined cap	Cool, 4°C; store in dark, 0 008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
PCBs[11]	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitroaromatics & Isophorone[11]	G, Teflon-lined cap	Cool, 4°C, 0 008% $Na_2S_2O_3$[5], store in dark	7 days until extraction; 40 days after extraction
Polynuclear Aromatic Hydrocarbons (PAHs)[11],[14]	G, Teflon-lined cap	Cool, 4°C, 0 008% $Na_2S_2O_3$[5], store in dark	7 days until extraction, 40 days after extraction
Haloethers[11]	G, Teflon-lined cap	Cool, 4°C; 0 008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
Dioxin/Furan (TCDD/TCDF)[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	7 days until extraction, 40 days after extraction

ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES
PAGE THREE

(1) Polyethylene (P) generally 500 ml or Glass (G) generally 1L
(2) Sample preservation should be performed immediately upon sample collection For composite chemical samples each aliquot should be preserved at the time of collection When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed
(3) When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172)
(4) Samples should be analyzed as soon as possible after collection The times listed are the maximum times that samples may be held before analysis and still be considered valid Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer periods, and has received a variance from the Regional Administrator
(5) Should only be used in the presence of residual chlorine
(6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments are made to determine if sulfide is present If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained The sample is filtered and then NaOH is added to pH 12
(7) Samples should be filtered immediately on site before adding preservative for dissolved metals
(8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds
(9) Sample receiving no pH adjustment must be analyzed within 7 days of sampling
(10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.
(11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9, samples preserved in this manner may be held for 7 days before extraction and for 40 days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re the analysis of benzidine).
(12) If 1,2-diphenylthydrazine is likely to be present, adjust the pH of the sample to 4 0±0 2 to prevent rearrangement to benzidine.
(13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.
(14) For the analysis of diphenylnitrosamine, add 0 008% $Na_2S_2O_3$ and adjust pH to 7-10 with NaOH within 24 hours of sampling.
(15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection For the analysis of aldrin, add 0 008% $Na_2S_2O_3$

ATTACHMENT C

DOT HAZARDOUS MATERIAL CLASSIFICATION (49 CFR 173.2a)

1. Radioactive material (except a limited quantity)
2. Division 2.3, Poisonous Gases
3. Division 2.1, Flammable Gas
4. Division 2.2, Nonflammable gas
5. Division 6.1, Poisonous Liquids, Packing Group 1 (poison by inhalation only)
6. Division 4.2, Pyrophoric Material
7. Division 4.1, Self-Reactive Material
8. Class 3, Flammable Liquids*
9. Class 8, Corrosive Material
10. Division 4.1, Flammable Solid*
11. Division 4.2, Spontaneously Combustible Materials*
12. Division 4.3, Dangerous When Wet Materials*
13. Division 5.1, Oxidizers*
14. Division 6.1, Poisonous Liquids or Solids (other than Packing Group 1)*
15. Combustible liquid
16. Class 9, Miscellaneous Hazardous Materials

* If a material has or meets the criteria for more than one hazard class, use the precedence of hazardous table on the following page for Classes 3 and 8 and Divisions 4.1, 4.2, 4.3, 5.1, and 6.1. The following table ranks those materials that meet the definition of Classes 3 and 8 and Divisions 4.1, 4.2, 4.3, 5.1, and 6.1.

ATTACHMENT C (Continued)

DOT HAZARDOUS MATERIAL CLASSIFICATION
(49 CFR 173.2a)

Class	Packing Group	4 2	4.3	5 1 I[(a)]	5 1 II[(a)]	5 1 III[(a)]	6 1 I (Dermal)	6 1 I (Oral)	6 1 II	6 1 III	8 I (Liquid)	8 I (Solid)	8 II (Liquid)	8 II (Solid)	8 III (Liquid)	8 III (Solid)
3	I						3	3	3	3	3	[(c)]	3	[(c)]	3	[(c)]
3	II						3	3	3	3	8	[(c)]	3	[(c)]	3	[(c)]
3	III						6 1	6 1	6.1	3[(d)]	8	[(c)]	8	[(c)]	3	[(c)]
4.1	II[b]	4 2	4 3	5 1	4 1	4 1	6 1	6 1	4 1	4 1	[(c)]	8	[(c)]	4.1	[(c)]	4 1
4 1	III[b]	4.2	4 3	5 1	4.1	4 1	6 1	6 1	6.1	4.1	[(c)]	8	[(c)]	8	[(c)]	4 1
4.2	II		4 3	5 1	4 2	4.2	6 1	6 1	4 2	4.2	[(c)]	8	[(c)]	4 2	[(c)]	4 2
4.2	III		4 3	5 1	4 2	4 2	6 1	6 1	6 1	4.2	[(c)]	8	[(c)]	8	[(c)]	4.2
4 3	I			5 1	4 3	4.3	6 1	4 3	4.3	4 3	4 3	4 3	4.3	4 3	4 3	4 3
4 3	II			5.1	4 3	4 3	6 1	4 3	4.3	4 3	8	8	8	4 3	4 3	4 3
4.3	III			5 1	4 3	4 3	6 1	6 1	6 1	4.3	8	8	8	8	4.3	4 3
5.1	I[a]						5 1	5 1	5 1	5.1	5 1	5 1	5 1	5 1	5 1	5 1
5 1	II[a]						6 1	5 1	5.1	5 1	8	8	8	5 1	5 1	5 1
5 1	III[a]						6.1	6 1	6 1	5 1	8	8	8	8	5.1	5 1
6.1	I, Dermal										8	6.1	6 1	6 1	6 1	6.1
6 1	I, Oral										8	6.1	6 1	6 1	6 1	6 1
6.1	II, Inhalation										8	6.1	6.1	6.1	6 1	6.1
6 1	II, Dermal										8	6.1	8	6.1	6.1	6.1
6 1	II, Oral										8	8	8	6.1	6 1	6 1
6 1	III										8	8	8	8	8	8

(a) There are at present no established criteria for determining Packing Groups for liquids in Division 5.1 At present, the degree of hazard is to be assessed by analogy with listed substances, allocating the substances to Packing Group I, Great, Group II, Medium; or Group III, Minor Danger.

(b) Substances of Division 4 1 other than self-reactive substances

(c) Denotes an impossible combination

(d) For pesticides only, where a material has the hazards of Class 3, Packing Group III, and Division 6 1, Packing Group III, the primary hazard is Division 6.1, Packing Group III.

ATTACHMENT D

GUIDE FOR HAZARDOUS MATERIALS SHIPPERS

USE OF GUIDE - This guide is presented as an aid to shippers of hazardous materials. It does not contain or refer to all of the DOT requirements for shipping hazardous materials. For specific details, refer to all of the DOT requirements for shipping hazardous materials, as provided in the Code of Federal Regulations (CFR), Title 49, Transportation, Parts 100-199.

The following is offered as a step-by-step procedure to aid in compliance with the applicable DOT regulations.

STEP 1 - DETERMINE THE PROPER SHIPPING NAME. The shipper must determine the proper shipping name of the materials as listed in the Hazardous Materials Table, 49 CFR 172.101, Column (2).

STEP 2 - DETERMINE THE HAZARD CLASS OR CLASSES.

a. Refer to the Table, 49 CFR 172.101, Column (3), and locate the hazard class of the material.
b. If more than one class is shown for the proper shipping name, determine the proper class by definition.
c. If the materials have more than one hazard, classify the material based on the order of hazards in 49 CFR 173.2.

STEP 3 - SELECT THE PROPER IDENTIFICATION NUMBERS.

a. Refer to the Table, 49 CFR 172.101, Column (3a), and select the Identification Number (ID) that corresponds to the proper shipping name and hazard class.
b. Enter the ID number(s) on the shipping papers and display them, as required, on packagings, placards and/or orange panels.

STEP 4 - DETERMINE THE MODE(S) OF TRANSPORT TO ULTIMATE DESTINATION.

a. As a shipper, you must assure yourself that the shipment complies with various modal requirements.
b. The modal requirements may affect the following: (1) Packaging; (2) Quantity per Package; (3) Marking; (4) Labeling; (5) Shipping Papers; and (6) Certification.

STEP 5 - SELECT THE PROPER LABEL(S) AND APPLY AS REQUIRED.

a. Refer to the Table, 49 CFR 172.101, Column (4) for required labels.
b. For details on labeling refer to (1) Additional Labels, 49 CFR 172.402; (2) Placement of Labels, 49 CFR 172.406; (3) Packagings (Mixed or Consolidated), 49 CFR 172.404(a) and (h); (4) Packages Containing Samples, 49 CFR 172.402(h); (5) Radioactive Materials, 49 CFR 172.403; and (6) Authorized Label Modifications, 49 CFR 172.405.

STEP 6 - DETERMINE AND SELECT THE PROPER PACKAGES.

a. Refer to the Table, 49 CFR 172.101, Column (5a) for exceptions and Column (5b) for specification packagings. Consider the following when selecting an authorized package: Quantity per Package; Cushioning Material, if required; Proper Closure and Reinforcement; Proper Pressure; Outage; etc., as required.
b. If packaged by a prior shipper, make sure the packaging is correct and in proper condition for transportation.

ATTACHMENT D (Continued)
GUIDE FOR HAZARDOUS MATERIALS SHIPPERS

STEP 7 - MARK THE PACKAGING (INCLUDING OVERPACKS).

a. Apply the required markings (49 CFR 172.300); Proper shipping name and ID number, when required (49 CFR 172.301); Name and address of Consignee or Consignor (49 CFR 172.306).
b. For details and other required markings, see 49 CFR 172.300 through 172.338.

STEP 8 - PREPARE THE SHIPPING PAPERS.

a. The basic requirements for preparing shipping papers include Proper Shipping Name; Hazard Class; ID Number; Total Quantity; Shipper's Certification; and Emergency Response Telephone Number.
b. Make all entries on the shipping papers using the information required and in proper sequence (49 CFR 172.202).

STEP 9 - CERTIFICATION.

a. Each shipper must certify by printing (manually or mechanically) on the shipping papers that the materials being offered for shipment are properly classified, described, packaged, marked and labeled, and in proper condition for transportation according to the applicable DOT Regulations (49 CFR 172.202).

STEP 10 - LOADING, BLOCKING, AND BRACING. When hazardous materials are loaded into the transport vehicle or freight container, each package must be loaded, blocked, and braced in accordance with the requirements for mode of transport.

a. If the shipper loads the freight container or transport vehicle, the shipper is responsible for the proper loading, blocking, and bracing of the materials.
b. If the carrier does the loading, the carrier is responsible.

STEP 11 - DETERMINE THE PROPER PLACARD(S). Each person who offers hazardous materials for transportation must determine that the placarding requirements have been met.

a. For Highway, unless the vehicle is already correctly placarded, the shipper must provide the required placard(s) and required ID number(s) (49 CFR 172.506).
b. For Rail, if loaded by the shipper, the shipper must placard the rail car if placards are required (49 CFR 172.508).
c. For Air and Water shipments, the shipper has the responsibility to apply the proper placards.

STEP 12 - HAZARDOUS WASTE/HAZARDOUS SUBSTANCE.

a. If the material is classed as a hazardous waste or hazardous substance, most of the above steps will be applicable.
b. Pertinent Environmental Protection Agency regulations are found in the Code of Federal Regulations, Title 40, Part 262.

As a final check and before offering the shipment for transportation, visually inspect the shipment. The shipper should ensure that emergency response information is on the vehicle for transportation of hazardous materials.

Revised March 1995.

ATTACHMENT E

HAZARDOUS MATERIALS SHIPPING CHECK LIST

PACKAGING

1. Check DOT 173.24 for appropriate type of package for hazardous substance.
2. Check for container integrity, especially the closure.
3. Check for sufficient absorbent material in package.
4. Check for sample tags and log sheets for each sample and for chain-of-custody record.

SHIPPING PAPERS

1. Check that entries contain only approved DOT abbreviations.
2. Check that entries are in English.
3. Check that hazardous material entries are specially marked to differentiate them from any nonhazardous materials being sent using same shipping paper.
4. Be careful that all hazardous classes are shown for multiclass materials.
5. Check total amounts by weight, quantity, or other measures used.
6. Check that any limited-quantity exemptions are so designated on the shipping paper.
7. Check that certification is signed by shipper.
8. Make certain driver signs for shipment.

RCRA MANIFEST

1. Check that approved state/federal manifests are prepared.
2. Check that transporter has the following: valid EPA identification number, valid driver's license, valid vehicle registration, insurance protection, and proper DOT labels for materials being shipped.
3. Check that destination address is correct.
4. Check that driver knows where shipment is going.
5. Check that the driver is aware of emergency procedures for spills and accidents.
6. Make certain driver signs for shipment.
7. Make certain one copy of executed manifest and shipping document is retained by shipper.

ATTACHMENT F
DOT SEGREGATION AND SEPARATON CHART

Class or Division	Notes	1.1-1 2	1 3	1 4	1 5	1 6	2 1	2.2	2.3 gas Zone A*	2 3 gas Zone B*	3	4 1	4 2	4 3	5.1	5 2	6.1 liquids PG-I Zone A*	7	8 liquids only
Explosives 1 1 and 1 2	A	*	*	*	*	*	X	X	X	X	X	X	X	X	X	X	X	X	X
Explosives 1 3		*	*	*	*	*	X		X	X	X		X	X	X	X	X		X
Explosives . 1 4		*	*	*	*	*	O		O	O	O		O				O		O
Very insensitive explosives.. 1.5	A	*	*	*	*	*	X	X	X	X	X	X	X	X	X	X	X	X	X
Extremely insensitive explosives 1 6		*	*	*	*	*													
Flammable gases .2 1		X	X	O	X				X	O							O	O	
Non-toxic, non-flammable gases .. 2 2		X			X														
Poisonous gas - Zone A** 2 3		X	X	O	X		X				X	X	X	X	X	X			X
Poisonous gas - Zone B** 2.3		X	X	O	X		O				O	O	O	O	O	O			O
Flammable liquids 3		X	X	O	X				X	O					O		X		
Flammable solids .. 4 1		X			X				X	O							X		O
Spontaneously combustible matenals 4.2		X	X	O	X				X	O							X		X
Dangerous-when-wet materials. 4.3		X	X		X				X	O							X		O
Oxidizers 5 1	A	X	X		X				X	O	O						X		O
Organic peroxdes.... 5.2		X	X		X				X	O							X		O
Poisonous liquids PG I - Zone A** 6.1		X	X	O	X		O				X	X	X	X	X	X			X
Radioactive matenals 7		X			X		O												
Corrosive liquids . . 8		X	X	O	X				X	O		O	X	O	O	O	X		

No entry means that the matenals are compatible (have no restrictions)

X These matenals may not be loaded, transported, or stored together in the same vehicle or facility.
O The matenals may not be loaded, transported, or stored together in the same vehicle or facility unless they are separated for 4 feet on all sides.
* Check the explosives compatibility chart in 49 CFR 179 848(f)
A Ammonium nitrate fertilizers may be stored with Division 1 1 matenals
** Denotes inhalation hazardous for poisons, consult field team leader or project manager if you encounter a matenal in this class 1 before shipment.

ATTACHMENT G
LITHIUM BATTERY SHIPPING PAPERS

3224637861

Two completed and signed copies of this Declaration must be handed to the operator.

WARNING

Failure to comply in all respects with the applicable Dangerous Goods Regulations may be in breach of the applicable law, subject to legal penalties. This Declaration must not, in any circumstances, be completed and/or signed by a consolidator, a forwarder or an IATA cargo agent.

TRANSPORT DETAILS

This shipment is within the limitations prescribed for: *(delete non applicable)*

PASSENGER AND CARGO AIRCRAFT | CARGO AIRCRAFT ONLY

Airport of Departure:

Airport of Destination: 19CYS

Shipment type: *(delete non-applicable)* ~~RADIOACTIVE~~ | NON-RADIOACTIVE

NATURE AND QUANTITY OF DANGEROUS GOODS

Dangerous Goods Identification: Proper Shipping Name	Class or Division	UN or ID No.	Subsidiary Risk	Quantity and type of packing	Packing Inst.	Authorization
LITHIUM BATTERIES CONTAINED IN EQUIPMENT	9	UN3091		1 PLASTIC BOX X 55 GRAMS	912 II	PER CA-9206009

Additional Handling Information

1 HERMIT SERIES DATALOGGER X 55 GRAMS (11 GRAMS/CELL)

I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in the proper condition for transport by air according to the applicable International and National Government Regulations.

Name/Title of Signatory

Place and Date

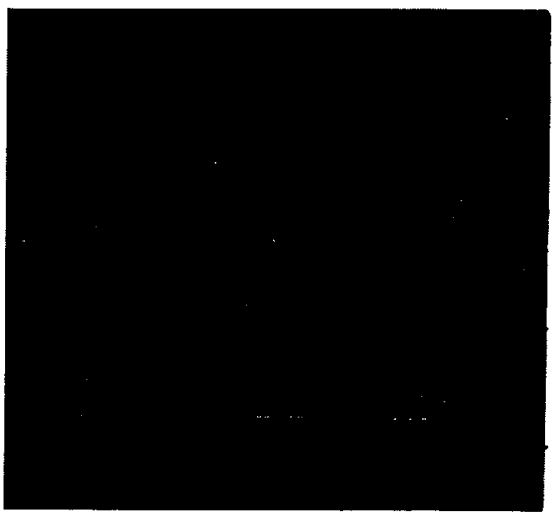
Signature *(see warning above)*

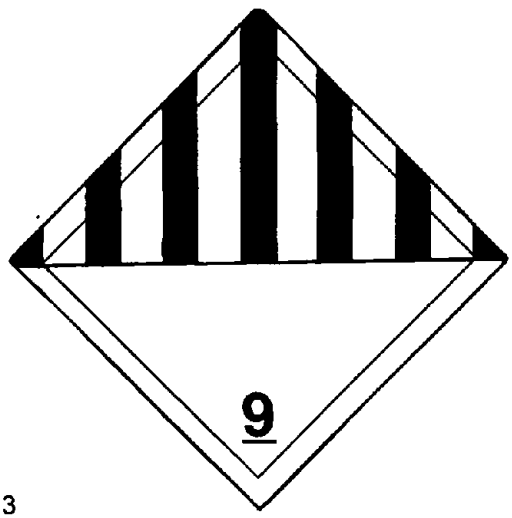
Emergency Telephone Number (Required for US Origin or Destination Shipments)

800-535-5053

IF ACCEPTABLE FOR PASSENGER AIRCRAFT, THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS, OR TREATMENT.

ATTACHMENT G (CONTINUED)
LITHIUM BATTERY SHIPPING PAPERS





3

LITHIUM BATTERIES CONTAINED IN EQUIPMENT.
UN-3091.
SHIPPED UNDER CA-9206009

TETRA TECH NUS, INC.	STANDARD OPERATING PROCEDURES	Number SA-6.3	Page 1 of 37
		Effective Date 01/00	Revision 1
		Applicability Tetra Tech NUS, Inc.	
		Prepared Earth Sciences Department	
Subject FIELD DOCUMENTATION		Approved D. Senovich	

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

ATTACHMENTS (EXAMPLES) **PAGE**

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs and reports generally initiated and maintained for documenting Tetra Tech NUS field activities.

2.0 SCOPE

Documents presented within this procedure (or equivalents) shall be used for all Tetra Tech NUS field activities, as applicable. Other or additional documents may be required by specific client contracts or project planning documents.

3.0 GLOSSARY

None

4.0 RESPONSIBILITIES

Project Manager (PM) - The Project Manager is responsible for obtaining hardbound, controlled-distribution logbooks (from the appropriate source), as needed. In addition, the Project Manager is responsible for placing all field documentation used in site activities (i.e., records, field reports, sample data sheets, field notebooks, and the site logbook) in the project's central file upon the completion of field work.

Field Operations Leader (FOL) - The Field Operations Leader is responsible for ensuring that the site logbook, notebooks, and all appropriate and current forms and field reports illustrated in this guideline (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time-frame.

5.0 PROCEDURES

5.1 Site Logbook

5.1.1 General

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major onsite activities are documented. At a minimum, the following activities/events shall be recorded or referenced (daily) in the site logbook:

- All field personnel present
- Arrival/departure of site visitors
- Arrival/departure of equipment
- Start and/or completion of borehole, trench, monitoring well installation, etc.
- Daily onsite activities performed each day
- Sample pickup information
- Health and Safety issues (level of protection observed, etc.)
- Weather conditions

A site logbook shall be maintained for each project. The site logbook shall be initiated at the start of the first onsite activity (e.g., site visit or initial reconnaissance survey). Entries are to be made for every day that onsite activities take place which involve Tetra Tech NUS or subcontractor personnel. Upon completion of the fieldwork, the site logbook must become part of the project's central file.

The following information must be recorded on the cover of each site logbook:

- Project name
- Tetra Tech NUS project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2), but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the field notebook in which the measurements are recorded (see Attachment A).

All logbook, notebook, and log sheet entries shall be made in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, the data shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook pages used must be signed and dated. The site logbook must also be signed by the Field Operations Leader at the end of each day.

5.1.2 Photographs

When movies, slides, or photographs are taken of a site or any monitoring location, they must be numbered sequentially to correspond to logbook/notebook entries. The name of the photographer, date, time, site location, site description, and weather conditions must be entered in the logbook/notebook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook/notebook. If possible, such techniques shall be avoided, since they can adversely affect the accuracy of photographs. Chain-of-custody procedures depend upon the subject matter, type of film, and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Once processed, the slides of photographic prints shall be consecutively numbered and labeled according to the logbook/notebook descriptions. The site photographs and associated negatives must be docketed into the project's central file.

5.2 Field Notebooks

Key field team personnel may maintain a separate dedicated field notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a separate field notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a field notebook.

5.3 Sample Forms

A summary of the forms illustrated in this procedure is shown as the listing of Attachments in the Table of Contents for this SOP. Forms may be altered or revised for project-specific needs contingent upon client

approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOP.

5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results

5.3.1.1 Sample Log Sheet

Sample Log Sheets are used to record specified types of data while sampling. Attachments B-1 to B-4 are examples of Sample Log Sheets. The data recorded on these sheets are useful in describing the waste source and sample as well as pointing out any problems, difficulties, or irregularities encountered during sampling. A log sheet must be completed for each sample obtained, including field quality control (QC) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B-5. Adhesive labels must be completed and applied to every sample container. Sample labels can usually be obtained from the appropriate Program source electronically generated in-house, or are supplied from the laboratory subcontractor.

5.3.1.3 Chain-of-Custody Record Form

The Chain-of-Custody (COC) Record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site. One carbonless copy of the completed COC form is retained by the field crew, one copy is sent to the Project Manager, while the original is sent to the laboratory. The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the first cooler. The COC form should then state how many coolers are included with that shipment. An example of a Chain-of-Custody Record form is provided as Attachment B-6. Once the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed COC form (any discrepancies between the sample labels and COC form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the Tetra Tech NUS Project Manager). The COC form is signed and copied. The laboratory will retain the copy while the original becomes part of the samples' corresponding analytical data package.

5.3.1.4 Chain-of-Custody Seal

Attachment B-7 is an example of a custody seal. The Custody seal is an adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transport to the laboratory. The COC seals are signed and dated by the samplers and affixed across the opening edges of each cooler containing environmental samples. COC seals may be available from the laboratory; these seals may also be purchased from a supplier.

5.3.1.5 Field Analytical Log Sheets for Geochemical Parameters

Field Analytical Log Sheets (Attachment B-8) are used to record geochemical and/or natural attenuation field test results. Attachments B-8 (3-page form) should be used when applicable.

5.3.2 Hydrogeological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

A groundwater level measurement sheet, shown in Attachment C-1 must be filled out for each round of water level measurements made at a site.

5.3.2.2 Data Sheet for Pumping Test

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. The pumping test data sheet (Attachment C-2) facilitates this task by standardizing the data collection format, and allowing the time interval for collection to be laid out in advance.

5.3.2.3 Packer Test Report Form

A packer test report form shown in Attachment C-3 must be completed for each well upon which a packer test is conducted.

5.3.2.4 Summary Log of Boring

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring, or Boring Log, (Attachment C-4) is used for this purpose and must be completed for each soil boring performed. In addition, if volatile organics are monitored on cores, samples, cuttings from the borehole, or breathing zone, (using a PID or FID), these results must be entered on the boring log at the appropriate depth. The "Remarks" column can be used to subsequently enter the laboratory sample number, the concentration of key analytical results, or other pertinent information. This feature allows direct comparison of contaminant concentrations with soil characteristics.

5.3.2.5 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock), different forms are used (see Attachments C-5 through C-9). Similar forms are used for flush-mount well completions.

5.3.2.6 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log (Attachment C-10) must be filled out by the responsible field geologist or sampling technician.

5.3.2.7 Miscellaneous Monitoring Well Forms

Monitoring Well Materials Certificate of Conformance (Attachment C-11) should be used as the project directs to document all materials utilized during each monitoring well installation.

The Monitoring Well Development Record (Attachment C-12) should be used as the project directs to document all well development activities.

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log (Attachment D) which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. An Equipment Calibration Log must be maintained for each electronic measuring device used in the field; entries must be made for each day the equipment is used.

5.4 Field Reports

The primary means of recording onsite activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation, but are not easily useful for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain onsite for extended periods of time and are thus not accessible for timely review by project management.

5.4.1 Daily Activities Report

To provide timely oversight of onsite contractors, Daily Activities Reports are completed and submitted as described below.

5.4.1.1 Description

The Daily Activities Report (DAR) documents the activities and progress for each day's field work. This report must be filled out on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring which involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors (Attachment E is an example of a Daily Activities Report).

5.4.1.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.4.1.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the Daily Activities Report to the Field Operations Leader (FOL) for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The DAR reports are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the Project Manager.

5.4.2 Weekly Status Reports

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

It should be noted that in addition to the summaries described herein, other summary reports may also be contractually required. Attachment F is an example of a Field Trip Summary Report form.

6.0 ATTACHMENTS

Attachment A	TYPICAL SITE LOGBOOK ENTRY
Attachment B-1	EXAMPLE GROUNDWATER SAMPLE LOG SHEET
Attachment B-2	EXAMPLE SURFACE WATER SAMPLE LOG SHEET
Attachment B-3	EXAMPLE SOIL/SEDIMENT SAMPLE LOG SHEET
Attachment B-4	CONTAINER SAMPLE LOG SHEET FORM
Attachment B-5	SAMPLE LABEL
Attachment B-6	CHAIN-OF-CUSTODY RECORD FORM
Attachment B-7	CHAIN-OF-CUSTODY SEAL
Attachment B-8	FIELD ANALYTICAL LOG SHEET
Attachment C-1	EXAMPLE GROUNDWATER LEVEL MEASUREMENT SHEET
Attachment C-2	EXAMPLE PUMPING TEST DATA SHEET
Attachment C-3	PACKER TEST REPORT FORM
Attachment C-4	EXAMPLE BORING LOG
Attachment C-5	EXAMPLE OVERBURDEN MONITORING WELL SHEET
Attachment C-5A	EXAMPLE OVERBURDEN MONITORING WELL SHEET (FLUSHMOUNT)
Attachment C-6	EXAMPLE CONFINING LAYER MONITORING WELL SHEET
Attachment C-7	EXAMPLE BEDROCK MONITORING WELL SHEET - OPEN HOLE WELL
Attachment C-8	EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK
Attachment C-9	EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK (FLUSHMOUNT)
Attachment C-10	EXAMPLE TEST PIT LOG
Attachment C-11	MONITORING WELL MATERIALS CERTIFICATE OF CONFORMANCE
Attachment C-12	MONITORING WELL DEVELOPMENT RECORD
Attachment D	EXAMPLE EQUIPMENT CALIBRATION LOG
Attachment E	EXAMPLE DAILY ACTIVITIES RECORD
Attachment F	FIELD TRIP SUMMARY REPORT

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: _____ DATE: _____

SITE LEADER: _____
PERSONNEL:

TtNUS	DRILLER	SITE VISITORS
_____	_____	_____
_____	_____	_____
_____	_____	_____

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenney and fire hoses were set up.
2. Drilling activities at well ____ resumes. Rig geologist was _____. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well _____.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _____.
4. Well _____ drilled. Rig geologist was _____. See Geologist's Notebook, No. 2, page ____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manger arrives on site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit _____.
8. Test pit _____ dug with cuttings placed in dump truck. Rig geologist was _____. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit ___ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel off site, gate locked.

_____

Field Operations Leader

ATTACHMENT B-1

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Domestic Well Data
[] Monitoring Well Data
[] Other Well Type: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____
Type of Sample:
[] Low Concentration
[] High Concentration

SAMPLING DATA:

Date: / Time:	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other
Method:								

PURGE DATA:

Date:	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Method:								
Monitor Reading (ppm):								
Well Casing Diameter & Material Type:								
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

ATTACHMENT B-2

Tetra Tech NUS, Inc. **SURFACE WATER SAMPLE LOG SHEET**

Page___ of ___

Project Site Name: _____ Sample ID No.: _____

Project No.: _____ Sample Location: _____

Sampled By: _____

C.O.C. No.: _____

[] Stream
[] Spring
[] Pond
[] Lake
[] Other: _____
[] QA Sample Type: _____

Type of Sample:
[] Low Concentration
[] High Concentration

SAMPLING DATA

	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (^{o}C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other
Date: / Time:								
Depth: / Method:								

SAMPLE COLLECTION INFORMATION

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

ATTACHMENT B-3

Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

Date: / Time: / Method: / Monitor Reading (ppm):	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)

COMPOSITE SAMPLE DATA:

Date: / Method: / Monitor Readings (Range in ppm):	Time	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

ATTACHMENT B-4

CONTAINER SAMPLE & INSPECTION SHEET

Tetra Tech NUS, Inc.

Page____ of ____

Project Site Name: _____
Project Number: _____
Site Identification: _____
Container Number(s): _____
Sample Type: 0 Grab
0 Composite

Sample ID No. _____
Sampled By: _____
C.O.C No _____
Concentration. 0 High
0 Medium
0 Low

CONTAINER SOURCE

DRUM:
0 Bung Top
0 Lever Lock
0 Bolted Ring
0 Other _____

TANK:
0 Plastic
0 Metal
0 Other _____

OTHER: _____

CONTAINER DESCRIPTION

COLOR: _____

CONDITION: _____

MARKINGS: _____

VOL. OF CONTENTS: _____

OTHER: _____

CONTAINER DISPOSITION

SAMPLED: _____

OPENED BUT NOT SAMPLED:
Reason _____
_____

NOT OPENED:
Reason _____
_____

CONTENTS DESCRIPTION

SINGLE PHASED: _____
_____

MULTIPHASE :

	Layer 1	Layer 2	Layer 3
Phase (Sol. or Liq.)	_____	_____	_____
Color	_____	_____	_____
Viscosity	L, M or H	L, M or H	L, M orH
% of Total Volume	_____	_____	_____

MONITOR READING:

SAMPLE and /or INSPECTION DATE & TIME:
_____HRS.

METHOD: _____

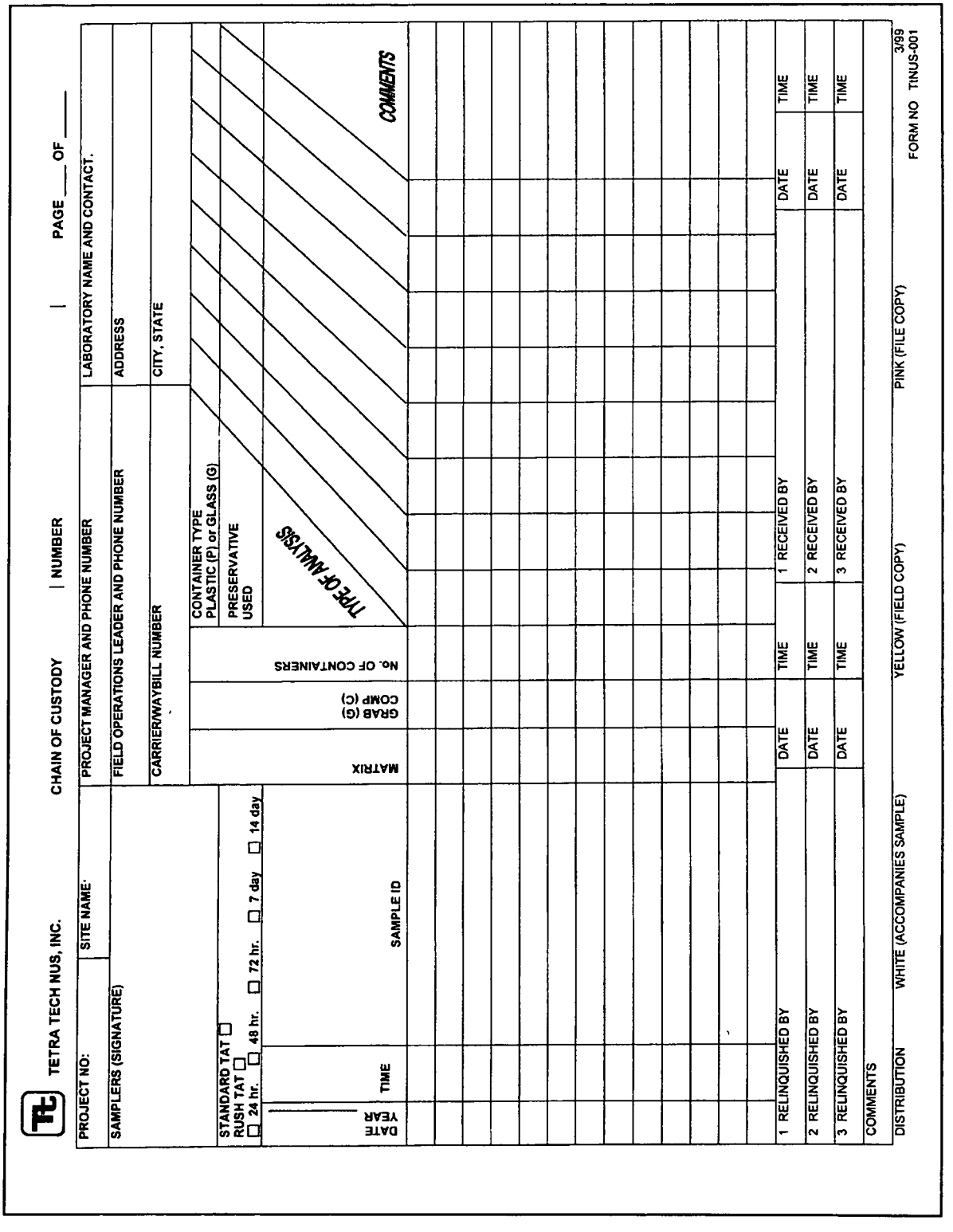
SAMPLER(S) and / or INSPECTOR(S) SIGNATURE:

ANALYSIS:

ATTACHMENT B-5

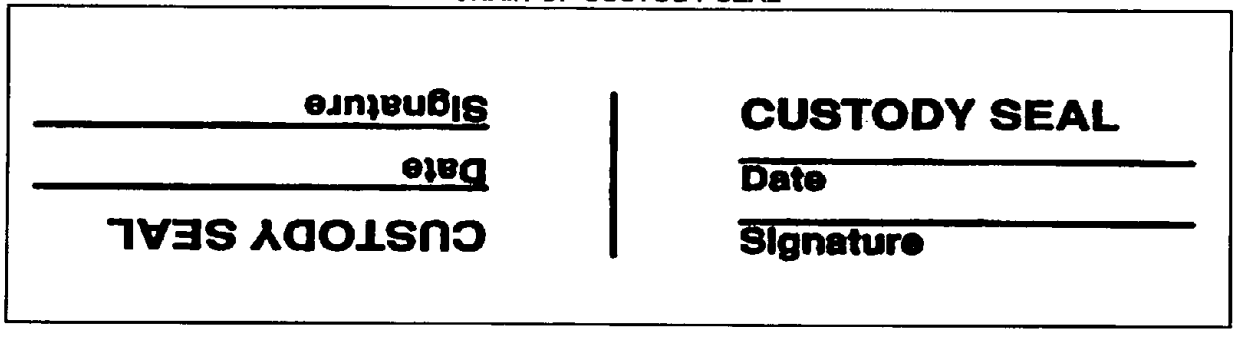
Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090	**Project:** **Site:** **Location:**	
Sample No:		**Matrix:**
Date:	**Time:**	**Preserve:**
Analysis:		
Sampled by:	**Laboratory:**	

ATTACHMENT B-6



ATTACHMENT B-7

CHAIN-OF-CUSTODY SEAL



ATTACHMENT B-8

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Tetra Tech NUS, Inc

Page __ of __

Project Site Name: _____ Sample ID No.: _____

Project No.: _____ Sample Location: _____

Sampled By: _____ Duplicate: ☐

Field Analyst: _____ Blank: ☐

Field Form Checked as per QA/QC Checklist (initials): _____

SAMPLING DATA

	Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Date.								
Time	(Visual)	(S.U.)	(mS/cm)	(°C)	(NTU)	(mg/l)	(%)	
Method								

SAMPLE COLLECTION/ANALYSIS INFORMATION

ORP (Eh) (+/- mv): _____ Electrode Make & Model: _____

Reference Electrode (circle one) Silver-Silver Chloride / Calomel / Hydrogen

Dissolved Oxygen:

Equipment: HACH Digital Titrator OX-DT CHEMetrics (Range: _____mg/L) Analysis Time: _____

Range Used	Range	Sample Vol	Cartridge	Multiplier
☐	1-5 mg/L	200 ml	0.200 N	0.01
☐	2-10 mg/L	100 ml	0.200 N	0.02

Titration Count	Multiplier	Concentration
_____	x 0.01 =	mg/L
_____	x 0.02 =	mg/L

CHEMetrics: _____mg/L

Notes:

Alkalinity:

Analysis Time: _____

Equipment: HACH Digital Titrator AL-DT CHEMetrics (Range. _____mg/L) Filtered. ☐

Range Used	Range	Sample Vol.	Cartridge	Multiplier	Titration Count	Multiplier	Concentration
☐	10-40 mg/L	100 ml	0.1600 N	0.1	_____ & _____	x 0.1 =	mg/L
☐	40-160 mg/L	25 ml	0.1600 N	0.4	_____ & _____	x 0.4 =	mg/L
☐	100-400 mg/L	100 ml	1.600 N	1.0	_____ & _____	x 1.0 =	mg/L
☐	200-800 mg/L	50 ml	1.600 N	2.0	_____ & _____	x 2.0 =	mg/L
☐	500-2000 mg/L	20 ml	1.600 N	5.0	_____ & _____	x 5.0 =	mg/L
☐	1000-4000 mg/L	10 ml	1.600 N	10.0	_____ & _____	x 10.0 =	mg/L

Parameter:	Hydroxide	Carbonate	Bicarbonate
Relationship:			

CHEMetrics: _____mg/L

Notes:

Standard Additions: ☐ Titrant Molarity: _____ Digits Required 1st.: _____ 2nd.: _____ 3rd.: _____

Carbon Dioxide:

Equipment: HACH Digital Titrator CA-DT CHEMetrics (Range: _____mg/L) Analysis Time: _____

Range Used.	Range	Sample Vol	Cartridge	Multiplier
☐	10-50 mg/L	200 ml	0.3636 N	0.1
☐	20-100 mg/L	100 ml	0.3636 N	0.2
☐	100-400 mg/L	200 ml	3.636 N	1.0
☐	200-1000 mg/L	100 ml	3.636 N	2.0

Titration Count		Concentration
_____	x 0.1 =	mg/L
_____	x 0.2 =	mg/L
_____	x 1.0 =	mg/L
_____	x 2.0 =	mg/L

CHEMetrics: _____mg/L

Notes:

Standard Additions: ☐ Titrant Molarity: _____ Digits Required 1st.: _____ 2nd.: _____ 3rd.: _____

ATTACHMENT B-8 (Continued)

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Tetra Tech NUS, Inc.

Page __ of __

Project Site Name: _____ Sample ID No.: _____

Project No.: _____ Sample Location: _____

Sampled By: _____ Duplicate: ☐

Field Analyst: _____ Blank: ☐

Field Form Checked as per QA/QC Checklist (initials): ☐

SAMPLE COLLECTION/ANALYSIS INFORMATION:

Sulfide (S^{2-}):

Equipment: DR-700 DR-8 __ HS-WR Color Wheel Other: _____ Analysis Time: _____

Program/Module: 610nm 93

Concentration: _____ mg/L Filtered. ☐

Notes: _____

Sulfate (SO_4^{2-}):

Equipment: DR-700 DR-8 __ Other: _____ Analysis Time: _____

Program/Module 91

Concentration: _____ mg/L Filtered: ☐

Standard Solution: ☐ Results _____

Standard Additions: ☐ Digits Required: 0.1ml:_____ 0.2ml:_____ 0.3ml:_____

Notes: _____

Nitrite (NO_2^--N): Analysis Time: _____

Equipment: DR-700 DR-8 __ Other: _____ Filtered: ☐

Program/Module: 60

Concentration: _____ mg/L Reagent Blank Correction: ☐

Standard Solution: ☐ Results: ☐

Notes: _____

Nitrate (NO_3^--N): Analysis Time: _____

Equipment: DR-700 DR-8 __ Other _____ Filtered: ☐

Program/Module: 55

Concentration. _____ mg/L

Nitrite Interference Treatment: ☐

Standard Solution: ☐ Results: _____ Reagent Blank Correction: ☐

Standard Additions: ☐ Digits Required: 0.1ml:_____ 0.2ml:_____ 0.3ml:_____

Notes _____

ATTACHMENT B-8 (Continued)

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Tetra Tech NUS, Inc. **Page __ of __**

Project Site Name: _____ Sample ID No.: _____

Project No.: _____ Sample Location: _____

Sampled By: _____ Duplicate: ☐

Field Analyst. _____ Blank: ☐

Field Form Checked as per QA/QC Checklist (initials): _____

SAMPLE COLLECTION/ANALYSIS INFORMATION:

Manganese (Mn^{2+}):

Equipment: DR-700 DR-8 __ HACH MN-5 Other: _____ Analysis Time: _____

Program/Module: 525nm 41

Concentration: _____ mg/L Filtered: ☐

Digestion: ☐

Standard Solution: ☐ Results: _____ Reagent Blank Correction. ☐

Standard Additions: ☐ Digits Required: 0.1ml _____ 0.2ml:_____ 0.3ml:_____

Notes: _____

Ferrous Iron (Fe^{2+}):

Equipment. DR-700 DR-8 __ IR-18C Color Wheel Other: _____ Analysis Time. _____

Program/Module. 500nm 33

Concentration: _____ mg/L Filtered: ☐

Notes: _____

Hydrogen Sulfide (H_2S):

Equipment: HS-C Other: _____ Analysis Time: _____

Concentration: _____ mg/L Exceeded 5.0 mg/L range on color chart: ☐

Notes _____

QA/QC Checklist: _____

All data fields have been completed as necessary: ☐

Correct measurement units are cited in the SAMPLING DATA block: ☐

Values cited in the SAMPLING DATA block are consistent with the Groundwater Sample Log Sheet: ☐

Mulitplication is correct for each *Multiplier* table: ☐

Final calulated concentration is within the appropriate *Range Used* block: ☐

Alkalinity *Relationship* is determined appropriatly as per manufacturer (HACH) instructions: ☐

QA/QC sample (e.g., Std. Additions, etc.) frequency is appropriate as per the project planning documents: ☐

Nitrite Interference treatment was used for Nitrate test if Nitrite was detected: ☐

Title block on each page of form is initialized by person who performed this QA/QC Checklist: ☐

ATTACHMENT C-1
EXAMPLE GROUNDWATER LEVEL MEASUREMENT SHEET

Tetra Tech NUS, Inc

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: _____ **Project No.:** _____
Location: _____ **Personnel:** _____
Weather Conditions: _____ **Measuring Device:** _____
Tidally Influenced: Yes ___ No ___ **Remarks:** _____

Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Total Well Depth (feet)*	Water Level Indicator Reading (feet)*	Thickness of Free Product (feet)*	Groundwater Elevation (feet)*	Comments

* All measurements to the nearest 0.01 foot

Page ___ of ___

ATTACHMENT C-2
EXAMPLE PUMPING TEST DATA SHEET

Tetra Tech NUS, Inc

PUMPING TEST DATA SHEET

PROJECT NAME _____ PUMPING WELL NUMBER _____
PROJECT NUMBER: _____ MEASURED WELL NUMBER: _____

[ ] PUMPING TEST [ ] STEP DRAW DOWN TEST

DATE(s) _____ MONITORING POINT. _____
MEASUREMENT METHOD _____ DEPTH CORRECTION (ft) _____
TEST NUMBER _____ PUMP SETTING (Ft below monitoring point): _____
STATIC WATER LEVEL (ft) _____ DISTANCE FROM PUMPING WELL (ft) _____
PERSONNEL _____
REMARKS _____

MILITARY TIME	ELAPSED TIME SINCE PUMP START OR STOP (Min.)	WATER LEVEL (Ft.)	CORRECTION (Ft.)	DRAW DOWN OR RECOVERY (Ft.)	PUMPING RATE (GPM)	FLOW METER READING (Gals.)	REMARKS

NOTE All measurements to nearest 0 01 foot measured from top of well riser pipe unless otherwise noted.

ATTACHMENT C-3

ATTACHMENT C-3

PACKER TEST REPORT FORM

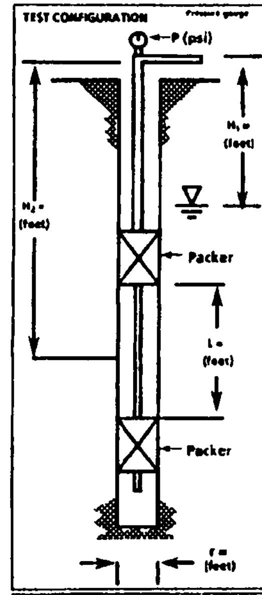
PROJECT: ______ PROJECT NO.: ______ TEST NO: ______ PAGE ___ OF ___

BORING NO.: ______ CASING DEPTH: ______ CONTRACTOR: ______ STATIC WATER LEVEL ______

TEST INTERVAL: ______ BY: ______ CHECKED: ______ PACKER PRESSURE ______

Flow Test					Calculated Results							
Pressure, p (psi)	Elapsed Time (min)	Flow Reading	Δ Flow, ΔQ (ft³)	Δ Flow, ΔQ (gal)	Flow Rate Q (gal/min)	H_1* (ft)	Hp(Ft) = 2.31 (psi)	H_2* (ft)	H = Hp + (H1 or H2)	Cp	K (ft/yr) = Cp Q/H	K (cm/sec) = 9.67 x 10⁻⁷ K (ft/yr)

TEST CONFIGURATION



Length of test section in feet, l	Cp			
	Drilling Bit Size			
	EX (1.5")	AX (1 7/8")	BX (2 3/8")	NX (3")
1	31,000	28,500	25,800	23,300
2	19,400	18,300	16,800	15,500
5	9,800	9,300	8,800	8,400
8	6,800	6,500	6,100	5,800
10	5,700	5,400	5,100	4,900
15	4,100	3,900	3,700	3,600
20	3,200	3,100	3,000	2,900

$CP = (1/(2 \pi L)) \ln(L/r)$ (70,315.5)
7.48 Gallons = 1 Ft³
1 psi = 2.31 ft head

* H_1 is used when the test length is below the water table
H_2 is used when the test length is above the water table

Remarks ______

ATTACHMENT C-4

Tetra Tech NUS, Inc.

BORING LOG

Page ___ of ___

PROJECT NAME: _____ BORING No.: _____
PROJECT NUMBER: _____ DATE: _____
DRILLING COMPANY: _____ GEOLOGIST: _____
DRILLING RIG: _____ DRILLER: _____

Sample No. and Type or RQD	Depth (Ft.) or Run No	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	MATERIAL DESCRIPTION: Color	MATERIAL DESCRIPTION: Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	PID/FID Reading (ppm): Sampler BZ	PID/FID Reading (ppm): Borehole**	PID/FID Reading (ppm): Driller BZ**

* When rock coring, enter rock brokeness

** Include monitor reading in 6 foot intervals @ borehole Increase reading frequency if elevated reponse read

Drilling Area

Remarks: _____ Background (ppm): ____

Converted to Well: Yes _____ No _____ Well I.D #: _____

ATTACHMENT C4 (Continued)

LEGEND
SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE-GRAINED SOILS
More Than Half of Material is LARGER Than No. 200 Sieve Size

FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights)			GROUP SYMBOL	TYPICAL NAMES
GRAVELS (50%(+)>1/4"∞	CLEAN GRAVELS (Low % Fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel-sand mixtures, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
	GRAVELS W/FINES (High % Fines)	Non-plastic fines (for identification procedures, see ML)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures.
		Plastic fines (for identification procedures, see CL)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.
SANDS 50%(+)<1/4"∞	CLEAN SANDS (Low % Fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	SW	Well graded sand, gravelly sands, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing	SP	Poorly graded sands, gravelly sands, little or no fines
	SANDS W/FINES (High % Fines)	Non-plastic fines (for identification procedures, see MCL)	SM	Silty sands, poorly graded sand-silt mixtures.
		Plastic fines (for identification procedures see CL)	SC	Clayey sands, poorly graded sand-clay mixtures.

FINE-GRAINED SOILS
More Than Half of Material is SMALLER Than No 200 Sieve Size

FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights)	Identification Procedures on Fraction Smaller than No 40 Sieve Size			GROUP SYMBOL	TYPICAL NAMES
	DAY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)		
SILTS AND CLAYS Liquid Limit <50	None to Slight	Quick to Slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity
	Medium to High	None to Very Slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
	Slight to Medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity
SILTS AND CLAYS Liquid Limit >50	Slight to Medium	Slow to None	Slight to Medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
	High to Very High	None	High	CH	Inorganic clays of high plasticity, fat clays.
	Medium to High	None to Very Slow	Slight to Medium	OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture			Pt	Peat and other organic soils

Boundary classifications Soils possessing characteristics of two groups are designated by combining group symbols. For example, GW-GC, well graded gravel-sand mixture with clay binder
All sieve sizes on this chart are U S Standard

DENSITY OF GRANULAR SOILS	
DESIGNATION	STANDARD PENETRATION RESISTANCE-BLOWS/FOOT
Very Loose	0-4
Loose	5-10
Medium Loose	11-30
Dense	31-50
Very Dense	Over 50

CONSISTENCY OF COHESIVE SOILS			
CONSISTENCY	UNC COMPRESSIVE STRENGTH (TONS/SQ. FT)	STANDARD PENETRATION RESISTANCE BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very Soft	Less than 0 25	0 to 2	Easily pentrated several inches by fist
Soft	0 25 to 0 50	2 to 4	Easily penetrated several inches by thumb
Medium Stiff	0 50 to 1 0	4 to 8	Can be penetrated several inches by thumb
Stiff	1 0 to 2 0	8 to 15	Readily indented by thumb
Very Stiff	2.0 to 4 0	15 to 30	Readily indented by thumbnail
Hard	More than 4 0	Over 30	Indented with difficulty by thumbnail.

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)		
Descriptive Terms	Screwdriver or Knife Effects	Hammer Effects
Soft	Easily Gouged	Crushes when pressed with hammer
Medium Soft	Can be Gouged	Breaks (one blow), crumbly edges
Medium Hard	Can be scratched	Breaks (one blow), sharp edges
Hard	Cannot be scratched	Breaks concholdally (several blows), sharp edges

ROCK BROKENESS		
Descriptive Terms	Abbreviation	Spacing
Very Broken	(V Br)	0-2"
Broken	(Br)	2"-1'
Blocky	(Bl)	1'-3"
Massive	(M.)	3'-10'

LEGEND

SOIL SAMPLES - TYPES

5-2" Split-Barrel Sample

ST-3" O.D Undisturbed Sample
O - Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES

X-NX (Conventional) Core (~2-1/8" O D)

Q-NQ (Wireline) Core (~1-7/8" O D)
Z - Other Core Sizes, Specify in Remarks

WATER LEVELS

12/18
▽ 12.61Initial Level w/Date & Depth

12/18

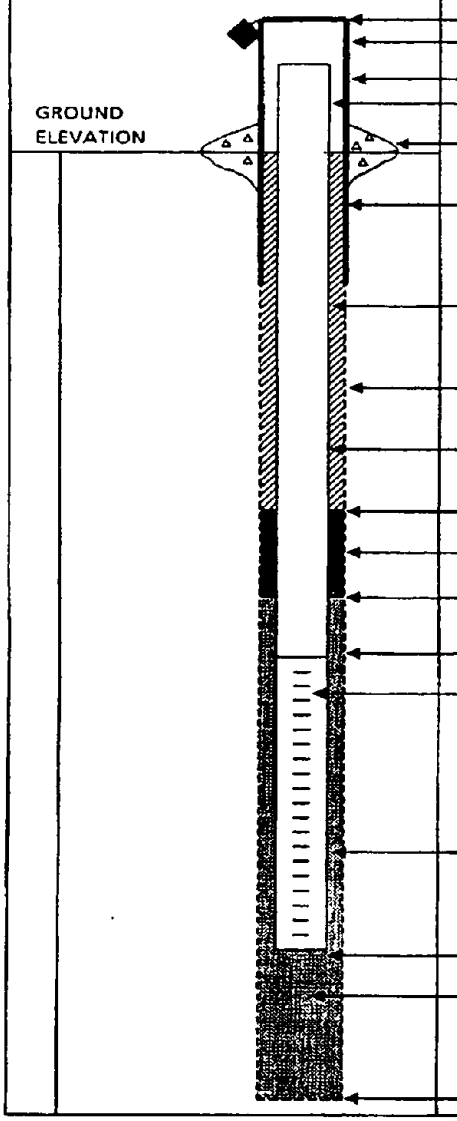
ATTACHMENT C-5
EXAMPLE OVERBURDEN MONITORING WELL SHEET

BORING NO.: _____

OVERBURDEN
MONITORING WELL SHEET

PROJECT _____ LOCATION _____
PROJECT NO. _____ BORING _____
ELEVATION _____ DATE _____
FIELD GEOLOGIST _____

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF SURFACE CASING _____
ELEVATION OF TOP OF RISER PIPE: _____

STICK - UP TOP OF SURFACE CASING _____
STICK - UP RISER PIPE . _____

TYPE OF SURFACE SEAL: _____

I. D. OF SURFACE CASING: _____
TYPE OF SURFACE CASING: _____

RISER PIPE I.D. _____
TYPE OF RISER PIPE: _____

BOREHOLE DIAMETER: _____

TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: _____ /

TYPE OF SEAL: _____

DEPTH TOP OF SAND PACK: _____

ELEVATION / DEPTH TOP OF SCREEN: _____ /

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

I.D. OF SCREEN: _____

TYPE OF SAND PACK: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____ /

ELEVATION / DEPTH BOTTOM OF SAND PACK: _____ /

TYPE OF BACKFILL BELOW OBSERVATION WELL: _____

ELEVATION / DEPTH OF HOLE: _____ /

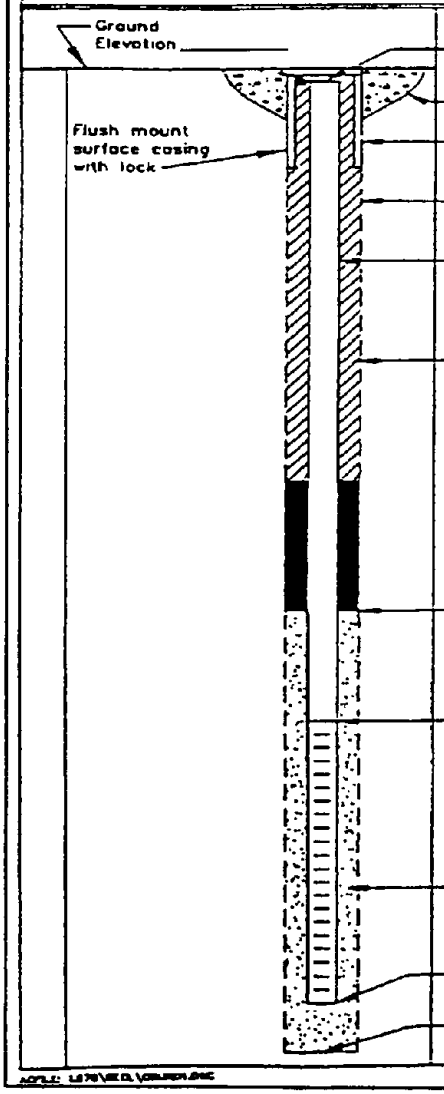
ATTACHMENT C-5A
EXAMPLE OVERBURDEN MONITORING WELL SHEET (FLUSHMOUNT)

BORING NO.: _____

MONITORING WELL SHEET

PROJECT _____ LOCATION _____
PROJECT NO. _____ BORING _____
ELEVATION _____ DATE _____
FIELD GEOLOGIST _____

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION TOP OF RISER: _____
TYPE OF SURFACE SEAL: _____
TYPE OF PROTECTIVE CASING: _____
I.D. OF PROTECTIVE CASING _____
DIAMETER OF HOLE: _____
TYPE OF RISER PIPE: _____
RISER PIPE I.D.: _____
TYPE OF BACKFILL/SEAL: _____
_____
DEPTH/ELEVATION TOP OF SAND: _____/_____
DEPTH/ELEVATION TOP OF SCREEN: _____/_____
TYPE OF SCREEN: _____
SLOT SIZE x LENGTH: _____
TYPE OF SAND PACK: _____
DIAMETER OF HOLE IN BEDROCK: _____
DEPTH/ELEVATION BOTTOM OF SCREEN: _____/_____
DEPTH/ELEVATION BOTTOM OF SAND: _____/_____
DEPTH/ELEVATION BOTTOM OF HOLE: _____/_____
BACKFILL MATERIAL BELOW SAND: _____

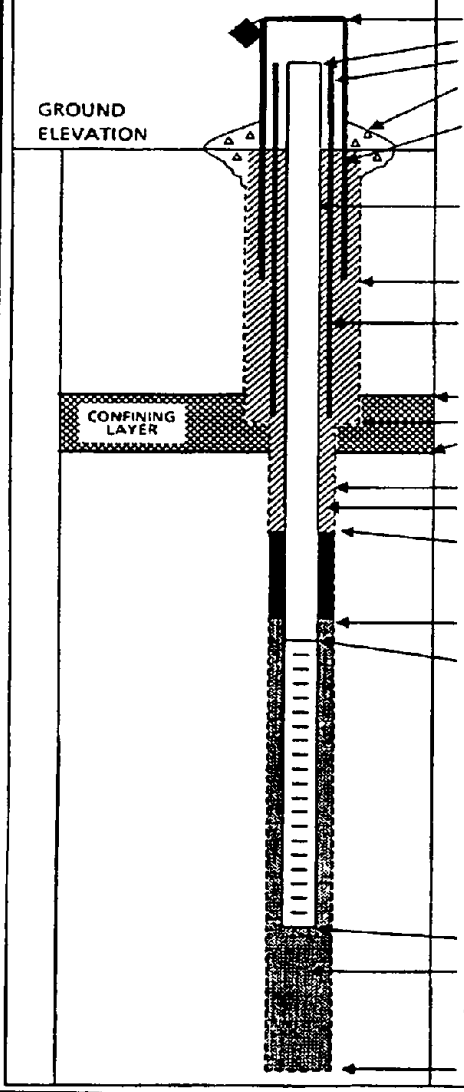
ATTACHMENT C-6
EXAMPLE CONFINING LAYER MONITORING WELL SHEET

BORING NO.: _____

CONFINING LAYER
MONITORING WELL SHEET

PROJECT _____ LOCATION _____
PROJECT NO. _____ BORING _____
ELEVATION _____ DATE _____
FIELD GEOLOGIST _____

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF SURFACE CASING . _____
ELEVATION OF TOP OF RISER PIPE: _____
ELEVATION TOP OF PERM. CASING: _____
TYPE OF SURFACE SEAL: _____
I.D. OF SURFACE CASING: _____
TYPE OF SURFACE CASING: _____
RISER PIPE I.D. _____
TYPE OF RISER PIPE: _____
BOREHOLE DIAMETER: _____
PERM. CASING I.D. _____
TYPE OF CASING & BACKFILL: _____
ELEVATION / DEPTH TOP CONFINING LAYER: _____
ELEVATION / DEPTH BOTTOM OF CASING: _____
ELEVATION / DEPTH BOT CONFINING LAYER: _____
BOREHOLE DIA. BELOW CASING: _____
TYPE OF BACKFILL: _____
ELEVATION / DEPTH TOP OF SEAL: _____
TYPE OF SEAL: _____
DEPTH TOP OF SAND PACK: _____
ELEVATION/DEPTH TOP OF SCREEN: _____
TYPE OF SCREEN: _____
TYPE OF SAND PACK: _____
ELEVATION / DEPTH BOTTOM OF SCREEN: _____
ELEVATION / DEPTH BOTTOM OF SAND PACK: _____
TYPE OF BACKFILL BELOW OBSERVATION WELL: _____
ELEVATION / DEPTH OF HOLE: _____

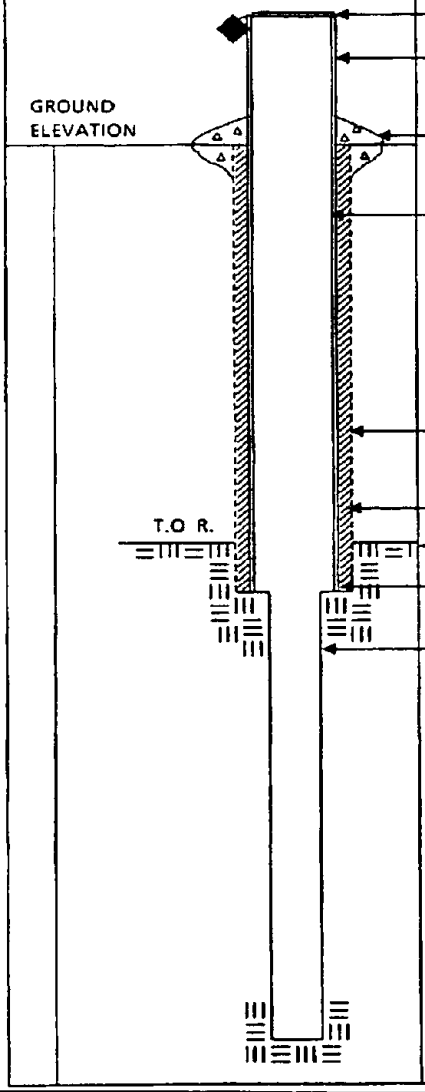
ATTACHMENT C-7
EXAMPLE BEDROCK MONITORING WELL SHEET - OPEN HOLE WELL

BORING NO : _____

BEDROCK
MONITORING WELL SHEET
OPEN HOLE WELL

PROJECT _____ LOCATION _____
PROJECT NO. _____ BORING _____
ELEVATION _____ DATE _____
FIELD GEOLOGIST _____

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE _____

TYPE OF SURFACE SEAL: _____

I.D. OF CASING: _____

TYPE OF CASING: _____

TEMP / PERM.: _____

DIAMETER OF HOLE: _____

TYPE OF CASING SEAL: _____

DEPTH TO TOP OF ROCK: _____

DEPTH TO BOTTOM CASING: _____

DIAMETER OF HOLE IN BEDROCK: _____

DESCRIBE IF CORE / REAMED WITH BIT:

_____

_____

_____

DESCRIBE JOINTS IN BEDROCK AND DEPTH:

_____

_____

_____

ELEVATION / DEPTH OF HOLE: _____ / _____

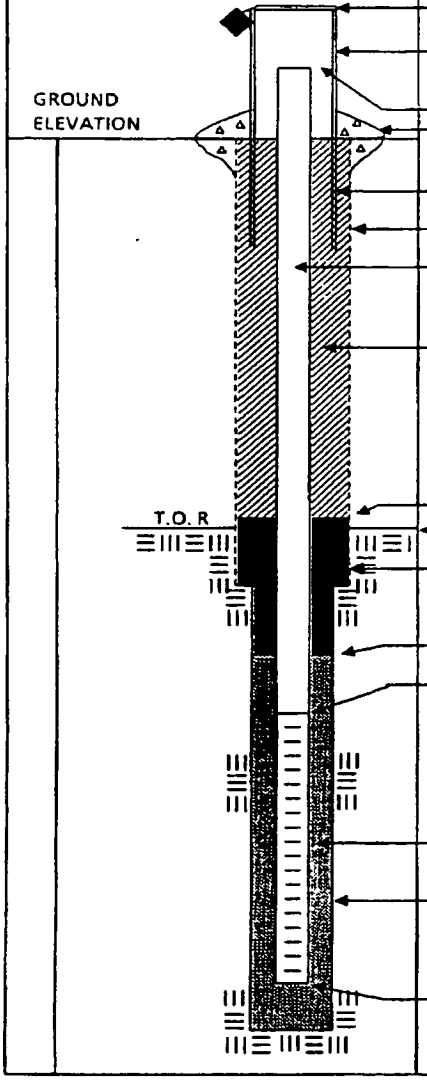
ATTACHMENT C-8
EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT _____ LOCATION _____
PROJECT NO. _____ BORING _____
ELEVATION _____ DATE _____
FIELD GEOLOGIST _____

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



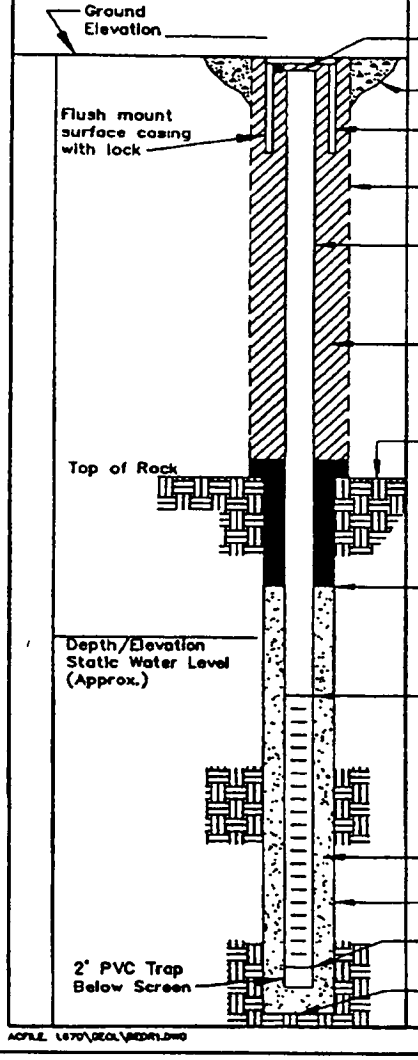
ELEVATION OF TOP OF SURFACE CASING: _____
STICK UP OF CASING ABOVE GROUND SURFACE: _____
ELEVATION TOP OF RISER: _____
TYPE OF SURFACE SEAL. _____
I D. OF SURFACE CASING. _____
DIAMETER OF HOLE: _____
RISER PIPE I.D.: _____
TYPE OF RISER PIPE: _____
TYPE OF BACKFILL: _____
ELEVATION / DEPTH TOP OF SEAL: _____ / _____
ELEVATION / DEPTH TOP OF BEDROCK: _____ / _____
TYPE OF SEAL: _____
ELEVATION / DEPTH TOP OF SAND: _____ / _____
ELEVATION / DEPTH TOP OF SCREEN: _____ / _____
TYPE OF SCREEN: _____
SLOT SIZE x LENGTH. _____
I.D. SCREEN: _____
TYPE OF SAND PACK: _____
DIAMETER OF HOLE IN BEDROCK:
CORE / REAM: _____
ELEVATION / DEPTH BOTTOM SCREEN: _____ / _____
ELEVATION / DEPTH BOTTOM OF HOLE: _____ / _____

ATTACHMENT C-9
EXAMPLE BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK (FLUSHMOUNT)

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT: _____ LOCATION: _____ DRILLER: _____
PROJECT NO.: _____ BORING: _____ DRILLING METHOD: _____
ELEVATION: _____ DATE: _____ DEVELOPMENT METHOD: _____
FIELD GEOLOGIST: _____



ELEVATION TOP OF RISER: _____
TYPE OF SURFACE SEAL: _____
TYPE OF PROTECTIVE CASING: _____
I.D. OF PROTECTIVE CASING: _____
DIAMETER OF HOLE: _____
TYPE OF RISER PIPE: _____
RISER PIPE I.D.: _____
TYPE OF BACKFILL/SEAL: _____
_____
DEPTH/ELEVATION TOP OF BEDROCK: ____/____
DEPTH/ELEVATION TOP OF SAND: ____/____
DEPTH/ELEVATION TOP OF SCREEN: ____/____
TYPE OF SCREEN: _____
SLOT SIZE x LENGTH: _____
TYPE OF SAND PACK: _____
DIAMETER OF HOLE IN BEDROCK: _____
DEPTH/ELEVATION BOTTOM OF SCREEN: ____/____
DEPTH/ELEVATION BOTTOM OF SAND: ____/____
DEPTH/ELEVATION BOTTOM OF HOLE: ____/____
BACKFILL MATERIAL BELOW SAND: _____

ATTACHMENT C-10
EXAMPLE TEST PIT LOG

TEST PIT LOG

Tetra Tech NUS, Inc.

PROJECT: _____ TEST PIT NO.:

PROJECT NO _____ DATE _____

LOCATION: _____

FIELD GEOLOGIST _____

DEPTH (ft.)	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION (Soil Density / Consistency, Color)	USCS	REMARKS

Test Pit Cross Section and / or Plan View

REMARKS _____

PHOTO LOG _____ TEST PIT _____

PAGE ____ OF ____

ATTACHMENT C-11
EXAMPLE CERTIFICATE OF CONFORMANCE

MONITORING WELL MATERIALS
CERTIFICATE OF CONFORMANCE

Well Designation: _____ Site Geologist: _____
Site Name: _____ Drilling Company: _____
Date Installed: _____ Driller: _____
Project Name: _____ Project Number: _____

Material	Brand/Description	Source/Supplier	Sample Collected ?
Well Casing			
Well Screen			
End Cap			
Drilling Fluid			
Drilling Fluid Additives			
Backfill Material			
Annular Filter Pack			
Bentonite Seal			
Annular Grout			
Surface Cement			
Protective Casing			
Paint			
Rod Lubricant			
Compressor Oil			

To the best of my knowledge, I certify that the above described materials were used during installation of this monitoring well.

Signature of Site Geologist: _____

ATTACHMENT C-12
EXAMPLE MONITORING WELL DEVELOPMENT RECORD

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Page ___ of ____

Site: _____ Depth to Bottom (ft.): _____ Project Name. _____
Well: _____ Static Water Level Before (ft.): _____ Project Number: _____
Date Installed: _____ Static Water Level After (ft.): _____ Site Geologist: _____
Date Developed _____ Screen Length (ft.): _____ Drilling Co.: _____
Dev. Method: _____ Specific Capacity: _____
Pump Type: _____ Casing ID (in): _____

Time	Estimated Sediment Thickness (Ft.)	Cumulative Water Volume (Gal.)	Water Level Readings (Ft. below TOC)	Temperature (Degrees C)	pH	Specific Conductance (Units _____)	Turbidity (NTU)	Remarks (odor, color, etc.)

ATTACHMENT D
EXAMPLE EQUIPMENT CALIBRATION LOG

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME: _____ INSTRUMENT NAME/MODEL: _____

SITE NAME: _____ MANUFACTURER: _____

PROJECT No.: _____ SERIAL NUMBER: _____

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks and Comments
			Pre-calibration	Post-calibration	Pre-calibration	Post-calibration		

ATTACHMENT E

Tetra Tech NUS, Inc.

DAILY ACTIVITIES RECORD

PROJECT NAME: _____ **PROJECT NUMBER:** _____

CLIENT: _____ **LOCATION:** _____

DATE: _____ **ARRIVAL TIME:** _____

Tt NUS PERSONNEL: _____ **DEPARTURE TIME:** _____

CONTRACTOR: _____ **DRILLER:** _____

ITEM	QUANTITY ESTIMATE	QUANTITY TODAY	PREVIOUS TOTAL QUANTITY	CUMULATIVE QUANTITY TO DATE

COMMENTS: _____

_____

_____

_____

APPROVED BY:

_____ _____

Tt NUS REPRESENTATIVE DRILLER

DATE: _____

ATTACHMENT F
FIELD TRIP SUMMARY REPORT
PAGE 1 OF 2

SUNDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

MONDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

TUESDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

WEDNESDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

ATTACHMENT F
PAGE 2 OF 2
FIELD TRIP SUMMARY REPORT

THURSDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

FRIDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

SATURDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

TETRA TECH NUS, INC.	STANDARD OPERATING PROCEDURES	Number SA-7.1	Page 1 of 9
		Effective Date 03/16/98	Revision 2
		Applicability Tetra Tech NUS, Inc.	
		Prepared Earth Sciences Department	
Subject DECONTAMINATION OF FIELD EQUIPMENT AND WASTE HANDLING		Approved D. Senovich	

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this procedure is to provide guidelines regarding the appropriate procedures to be followed when decontaminating drilling equipment, monitoring well materials, chemical sampling equipment and field analytical equipment.

2.0 SCOPE

This procedure addresses drilling equipment and monitoring well materials decontamination, as well as chemical sampling and field analytical equipment decontamination. This procedure also provides general reference information on the control of contaminated materials.

3.0 GLOSSARY

Acid - For decontamination of equipment when sampling for trace levels of inorganics, a 10% solution of nitric acid in deionized water should be used. Due to the leaching ability of nitric acid, it should not be used on stainless steel.

Alconox/Liquinox - A brand of phosphate-free laboratory-grade detergent.

Deionized Water - Deionized (analyte free) water is tap water that has been treated by passing through a standard deionizing resin column. Deionized water should contain no detectable heavy metals or other inorganic compounds at or above the analytical detection limits for the project.

Potable Water - Tap water used from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.

Solvent - The solvent of choice is pesticide-grade Isopropanol. Use of other solvents (methanol, acetone, pesticide-grade hexane, or petroleum ether) may be required for particular projects or for a particular purpose (e.g. for the removal of concentrated waste) and must be justified in the project planning documents. As an example, it may be necessary to use hexane when analyzing for trace levels of pesticides, PCBs, or fuels. In addition, because many of these solvents are not miscible in water, the equipment should be air dried prior to use. Solvents should not be used on PVC equipment or well construction materials.

4.0 RESPONSIBILITIES

Project Manager - Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) requirements.

Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved Standards Operating Procedures or as otherwise dictated by the approved project plan(s).

5.0 PROCEDURES

To ensure that analytical chemical results reflect actual contaminant concentrations present at sampling locations, the various drilling equipment and chemical sampling and analytical equipment used to acquire the environment sample must be properly decontaminated. Decontamination minimizes the potential for cross-contamination between sampling locations, and the transfer of contamination off site.

5.1 Drilling Equipment

Prior to the initiation of a drilling program, all drilling equipment involved in field sampling activities shall be decontaminated by steam cleaning at a predetermined area. The steam cleaning procedure shall be performed using a high-pressure spray of heated potable water producing a pressurized stream of steam. This steam shall be sprayed directly onto all surfaces of the various equipment which might contact environmental samples. The decontamination procedure shall be performed until all equipment is free of all visible potential contamination (dirt, grease, oil, noticeable odors, etc.) In addition, this decontamination procedure shall be performed at the completion of each sampling and/or drilling location, including soil borings, installation of monitoring wells, test pits, etc. Such equipment shall include drilling rigs, backhoes, downhole tools, augers, well casings, and screens. Where the drilling rig is set to perform multiple borings at a single area of concern, the steam-cleaning of the drilling rig itself may be waived with proper approval. Downhole equipment, however, must always be steam-cleaned between borings. Where PVC well casings are to be installed, decontamination is not required if the manufacturer provides these casings in factory-sealed, protective, plastic sleeves (so long as the protective packaging is not compromised until immediately before use).

The steam cleaning area shall be designed to contain decontamination wastes and waste waters and can be a lined excavated pit or a bermed concrete or asphalt pad. For the latter, a floor drain must be provided which is connected to a holding facility. A shallow above-ground tank may be used or a pumping system with discharge to a waste tank may be installed.

In certain cases such an elaborate decontamination pad is not possible. In such cases, a plastic lined gravel bed pad with a collection system may serve as an adequate decontamination area. Alternately, a lined sloped pad with a collection pump installed at the lower end may be permissible. The location of th steam cleaning area shall be onsite in order to minimize potential impacts at certain sites.

Guidance to be used when decontaminating drilling equipment shall include:

- As a general rule, any part of the drilling rig which extends over the borehole, shall be steam cleaned.
- All drilling rods, augers, and any other equipment which will be introduced to the hole shall be steam cleaned.
- The drilling rig, all rods and augers, and any other potentially contaminated equipment shall be decontaminated between each well location to prevent cross contamination of potential hazardous substances.

Prior to leaving at the end of each work day and/or at the completion of the drilling program, drilling rigs and transport vehicles used onsite for personnel or equipment transfer shall be steam cleaned, as practicable. A drilling rig left at the drilling location does not need to be steam cleaned until it is finished drilling at that location.

Error! Bookmark not defined.**5.2 Sampling Equipment**

5.2.1 Bailers and Bailing Line

The potential for cross-contamination between sampling points through the use of a common bailer or its attached line is high unless strict procedures for decontamination are followed. For this reason, it is preferable to dedicate an individual bailer and its line to each sample point, although this does not eliminate the need for decontamination of dedicated bailers. For non-dedicated sampling equipment, the following conditions and/or decontamination procedures must be followed.

Before the initial sampling and after each successive sampling point, the bailer must be decontaminated. The following steps are to be performed when sampling for organic contaminants. Note: contract-specific requirements may permit alternative procedures.

- Potable water rinse
- Alconox or Liquinox detergent wash
- Scrubbing of the line and bailer with a scrub brush (may be required if the sample point is heavily contaminated with heavy or extremely viscous compounds)
- Potable water rinse
- Rinse with 10 percent nitric acid solution*
- Deionized water rinse
- Pesticide-grade isopropanol (unless otherwise required)
- Pesticide-grade hexane rinse**
- Copious distilled/Deionized water rinse
- Air dry

If sampling for volatile organic compounds (VOCs) only, the nitric acid, isopropanol, and hexane rinses may be omitted. Only reagent grade or purer solvents are to be used for decontamination. When solvents are used, the bailer must be thoroughly dry before using to acquire the next sample.

In general, specially purchased pre-cleaned disposable sampling equipment is not decontaminated (nor is an equipment rinsate blank collected) so long as the supplier has provided certification of cleanliness. If decontamination is performed on several bailers at once (i.e., in batches), bailers not immediately used may be completely wrapped in aluminum foil (shiny-side toward equipment) and stored for future use. When batch decontamination is performed, one equipment rinsate is generally collected from one of the bailers belonging to the batch before it is used for sampling.

It is recommended that clean, dedicated braided nylon or polypropylene line be employed with each bailer use.

5.2.2 Sampling Pumps

Most sampling pumps are low volume (less than 2 gpm) pumps. These include peristaltic, diaphragm, air-lift, pitcher and bladder pumps, to name a few. If these pumps are used for sampling from more than one sampling point, they must be decontaminated prior to initial use and after each use.

The procedures to be used for decontamination of sampling pumps compare to those used for a bailer except that the 10 percent nitric acid solution is omitted. Each of the liquid factions is to be pumped through the system. The amount of pumping is dependent upon the size of the pump and the length of the intake and discharge hoses. Certain types of pumps are unacceptable for sampling purposes. For peristaltic pumps, the tubing is replaced rather than cleaned.

An additional problem is introduced when the pump relies on absorption of water via an inlet or outlet hose. For organic sampling, this hose should be Teflon. Other types of hoses leach organics (especially phthalate esters) into the water being sampled or adsorb organics from the sampled water. For all other sampling, the hose should be Viton, polyethylene, or polyvinyl chloride (listed in order of preference).

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* Due to the leaching ability of nitric acid on stainless steel, this step is to be omitted if a stainless steel sampling device is being used and metals analysis is required with detection limits less than approximately 50 ppb.

** If sampling for pesticides, PCBs, or fuels.

Whenever possible, dedicated hoses should be used. It is preferable that these types of pumps not be used for sampling, only for purging.

5.2.3 Filtering Equipment

On occasion, the sampling plan may require acquisition of filtered groundwater samples. Field-filtering is addressed in SOP SA-6.1 and should be conducted as soon after sample acquisition as possible. To this end, three basic filtration systems are most commonly used: the in-line disposable Teflon filter, the inert gas over-pressure filtration system, and the vacuum filtration system.

For the in-line filter, decontamination is not required since the filter cartridge is disposable, however, the cartridge must be disposed of in an approved receptacle and the intake and discharge lines must still be decontaminated or replaced before each use.

For the over-pressure and the vacuum filtration systems, the portions of the apparatus which come in contact with the sample must be decontaminated as outlined in the paragraphs describing the decontamination of bailers. (Note: Varieties of both of these systems come equipped from the manufacturer with Teflon-lined surfaces for those that would come into contact with the sample. These filtration systems are preferred when decontamination procedures must be employed.)

5.2.4 Other Sampling Equipment

Field tools such as trowels and mixing bowls are to be decontaminated in the same manner as described above.

5.3 Field Analytical Equipment

5.3.1 Water Level Indicators

Water level indicators that come into contact with groundwater must be decontaminated using the following steps:

- Rinse with potable water
- Rinse with deionized water

Water level indicators that do not come in contact with the groundwater but may encounter incidental contact during installation or retrieval need only undergo the first and last steps stated above.

5.3.2 Probes

Probes (e.g., pH or specific-ion electrodes, geophysical probes, or thermometers) which would come in direct contact with the sample, will be decontaminated using the procedures specified above unless manufacturer's instructions indicate otherwise (e.g., dissolved oxygen probes). Probes that contact a volume of groundwater not used for laboratory analyses can be rinsed with deionized water. For probes which make no direct contact, (e.g., OVA equipment) the probe is self-cleaning when exposure to uncontaminated air is allowed and the housing can be wiped clean with paper-towels or cloth wetted with alcohol.

5.4 Waste Handling

For the purposes of these procedures, contaminated materials are defined as any byproducts of field activities that are suspected or known to be contaminated with hazardous substances. These byproducts

include such materials as decontamination solutions, disposable equipment, drilling muds, well-development fluids, and spill-contaminated materials and Personal Protection Equipment (PPE).

The procedures for obtaining permits for investigations of sites containing hazardous substances are not clearly defined at present. In the absence of a clear directive to the contrary by the EPA and the states, it must be assumed that hazardous wastes generated during field activities will require compliance with Federal agency requirements for generation, storage, transportation, or disposal. In addition, there may be state regulations that govern the disposal action. This procedure exclusively describes the technical methods used to control contaminated materials.

The plan documents for site activities must include a description of control procedures for contaminated materials. This planning strategy must assess the type of contamination, estimate the amounts that would be produced, describe containment equipment and procedures, and delineate storage or disposal methods. As a general policy, it is wise to select investigation methods that minimize the generation of contaminated spoils. Handling and disposing of potentially hazardous materials can be dangerous and expensive. Until sample analysis is complete, it is assumed that all produced materials are suspected of contamination from hazardous chemicals and require containment.

5.5 Sources of Contaminated Materials and Containment Methods

5.5.1 Decontamination Solutions

All waste decontamination solutions and rinses must be assumed to contain the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. The waste solution volumes could vary from a few gallons to several hundred gallons in cases where large equipment required cleaning.

Containerized waste rinse solutions are best stored in 55-gallon drums (or equivalent containers) that can be sealed until ultimate disposal at an approved facility. Larger equipment such as backhoes and tractors must be decontaminated in an area provided with an impermeable liner and a liquid collection system. A decontamination area for large equipment could consist of a bermed concrete pad with a floor drain leading to a buried holding tank.

5.5.2 Disposable Equipment

Disposable equipment that could become contaminated during use typically includes PPE, rubber gloves, boots, broken sample containers, and cleaning-wipes. These items are small and can easily be contained in 55-gallon drums with lids. These containers should be closed at the end of each work day and upon project completion to provide secure containment until disposed.

5.5.3 Drilling Muds and Well-Development Fluids

Drilling muds and well-development fluids are materials that may be used in groundwater monitoring well installations. Their proper use could result in the surface accumulation of contaminated liquids and muds that require containment. The volumes of drilling muds and well-development fluids used depend on well diameter and depth, groundwater characteristics, and geologic formations. There are no simple mathematical formulas available for accurately predicting these volumes. It is best to rely on the experience of reputable well drillers familiar with local conditions and the well installation techniques selected. These individuals should be able to estimate the sizes (or number) of containment structures required. Since guesswork is involved, it is recommended that an slight excess of the estimated amount of containers required will be available.

Drilling muds are mixed and stored in what is commonly referred to as a mud pit. This mud pit consists of a suction section from which drilling mud is withdrawn and pumped through hoses, down the drill pipe to the bit, and back up the hole to the settling section of the mud pit. In the settling section, the mud's velocity is reduced by a screen and several flow-restriction devices, thereby allowing the well cuttings to settle out of the mud/fluid.

The mud pit may be either portable above-ground tanks commonly made of steel (which is preferred) or stationary in-ground pits as depicted in Attachment A. The above-ground tanks have a major advantage over the in-ground pits because the above-ground tanks isolate the natural soils from the contaminated fluids within the drilling system. These tanks are also portable and can usually be cleaned easily.

As the well is drilled, the cuttings that accumulate in the settling section must be removed. This is best done by shoveling them into drums or other similar containers. When the drilling is complete, the contents of the above-ground tank are likewise shoveled or pumped into drums, and the tank is cleaned and made available for its next use.

If in-ground pits are used, they should not extend into the natural water table. They should also be lined with a bentonite-cement mixture followed by a layer of flexible impermeable material such as plastic sheeting. Of course, to maintain its impermeable seal, the lining material used would have to be nonreactive with the wastes. An advantage of the in-ground pits is that well cuttings do not necessarily have to be removed periodically during drilling because the pit can be made deep enough to contain them. Depending on site conditions, the in-ground pit may have to be totally excavated and refilled with uncontaminated natural soils when the drilling operation is complete.

When the above-ground tank or the in-ground pit is used, a reserve tank or pit should be located at the site as a backup system for leaks, spills, and overflows. In either case, surface drainage should be such that any excess fluid could be controlled within the immediate area of the drill site.

The containment procedure for well-development fluids is similar to that for drilling muds. The volume and weight of contaminated fluid will be determined by the method used for development. When a new well is pumped or bailed to produce clear water, substantially less volume and weight of fluid result than when backwashing or high-velocity jetting is used.

5.5.4 Spill-Contaminated Materials

A spill is always possible when containers of liquids are opened or moved. Contaminated sorbents and soils resulting from spills must be contained. Small quantities of spill-contaminated materials are usually best contained in drums, while larger quantities can be placed in lined pits or in other impermeable structures. In some cases, onsite containment may not be feasible and immediate transport to an approved disposal site will be required.

5.6 Disposal of Contaminated Materials

Actual disposal techniques for contaminated materials are the same as those for any hazardous substance, that is, incineration, landfilling, treatment, and so on. The problem centers around the assignment of responsibility for disposal. The responsibility must be determined and agreed upon by all involved parties before the field work starts. If the site owner or manager was involved in activities that precipitated the investigation, it seems reasonable to encourage his acceptance of the disposal obligation. In instances where a responsible party cannot be identified, this responsibility may fall on the public agency or private organization investigating the site.

Another consideration in selecting disposal methods for contaminated materials is whether the disposal can be incorporated into subsequent site cleanup activities. For example, if construction of a suitable

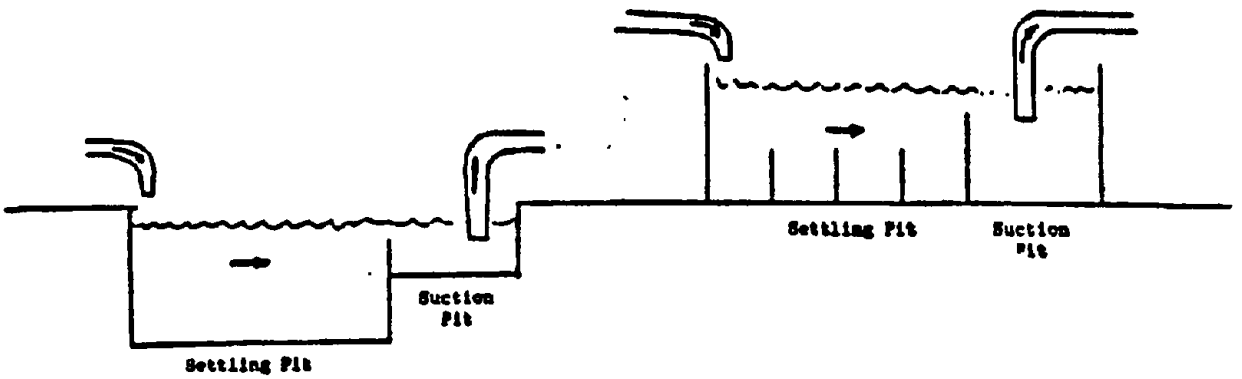
onsite disposal structure is expected, contaminated materials generated during the investigation should be stored at the site for disposal with other site materials. In this case, the initial containment structures should be evaluated for use as long-term storage structures. Also, other site conditions such as drainage control, security, and soil type must be considered so that proper storage is provided. If onsite storage is expected, then the containment structures should be specifically designed for that purpose.

6.0 REFERENCES

Brown & Root Environmental: Standard Operating Procedure No. 4.33, Control of Contaminated Material.

ATTACHMENT A

TWO TYPES OF MUD PITS USED IN WELL DRILLING



STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
Division of Groundwater and Individual Sewage Disposal Systems

Rules and Regulations for GROUNDWATER QUALITY

August 1996

Promulgated: May 1992
Amended: July 1993
May 1995
August 1996

Regulation 12-100-006

AUTHORITY: These Rules and Regulations are adopted in accordance with Chapter 42-35 pursuant to Chapters 46-12, 46-13.1, 23-18.9, 23-19.1, 42-17.6 and 42-17.1 of the Rhode Island General Laws of 1956, as amended

APPENDIX 1
Required Monitoring Well Construction Standards and Abandonment Procedures

1.0 Purpose: to provide minimum standards for; (a) the procurement of samples representative of groundwater; and (b) abandonment procedures for removing the vertical conduit to groundwater.

2.0 Applicability: The monitoring well construction standards herein apply to all permanent monitoring wells installed pursuant to these regulations. Pursuant to Rule 12.02 of these regulations, wells installed at the direction of other programs are exempt from Rules 4.0 through 12.0 of this Appendix. A monitoring well is designated permanent if it exists for more than 180 days. Rule 13 of this Appendix on monitoring well abandonment applies to all permanent and non-permanent monitoring wells subject to these regulations. Rule 13 also applies to those piezometers where improper abandonment would result in a reasonable likelihood of groundwater pollution. Additional requirements may be specified by the Director.

3.0 Prevention of Groundwater Pollution: During well construction and abandonment, every appropriate precaution shall be taken to prevent introducing pollutants into the groundwater. This shall include, but not be limited to, steam cleaning and washing of drilling equipment and proper cleaning and storage of well casing. Only potable water shall be used in well construction and abandonment unless otherwise approved by the Director.

4.0 Construction and Abandonment Standards: The procedures described in this Appendix incorporate minimum standards. The Director may waive the requirements and allow deviation from these procedures where such deviations are necessary to procure representative groundwater samples. All deviations from the procedures shall be documented and provided to the Director. If the Director determines that the deviation from these procedures will not or does not result in the procurement of samples representative of groundwater, the Director may require the installation of a new monitoring well.

5.0 Well Casing: All permanent groundwater monitoring wells shall be constructed of PVC well casing material. All casing shall have a minimum inside diameter of 2.0 inches. Monitoring wells constructed in unconsolidated material less than 100 feet in depth shall be constructed using a minimum of schedule 40 PVC. Wells greater than 100 feet shall be constructed using a minimum of schedule 80 PVC.

5.1 Assembly and Installation: All casing shall be constructed of flush threaded joints or threaded coupling joints. All joints shall be fitted with an "O" ring or wrapped with teflon tape. Solvent welded joints are not permissible without prior written permission of the Director.

5.2 Exceptions: The Director may allow alternate well casing material if the pollutant concentrations or geologic setting require an alternative construction. Alternative materials include but are not limited to: (a) Teflon; (b) stainless steel; or (c) uncoated or galvanized steel.

6.0 Well Screen: The well screen slot size shall retain at least 90% of the grain size of a filter pack or at least 60% of the grain size of the collapsed formation. Well screens on wells and piezometers shall not exceed the length necessary to collect a representative groundwater sample or to determine water table elevation. Well screens shall be factory slotted. A bottom cap and sump sediment trap shall be installed.

7.0 Filter Pack: The filter pack shall be chemically inert, well rounded and well sorted glass beads or silica-based sand or gravel of uniform grain size. The filter pack must minimize the amount of fine material entering the well and shall not inhibit the flow of water into the well. The filter pack shall extend a minimum of one foot, but no more than 5 feet above the well screen. The filter pack shall not pollute groundwater.

8.0 Sealing Requirements

8.1 Filter Pack Seal: All monitoring wells installed with a filter pack shall be constructed with a filter pack seal, such as bentonite flakes or pellets . The seal shall extend to approximately one foot above the filter pack and shall be properly hydrated.

8.2 Annular Space Seal: All monitoring wells shall be installed with an annular space seal that has a permeability of 1×10^{-7} centimeters per second or less. Materials that meet this criterion include but are not limited to neat cement grout and cement-bentonite grout. The annular space seal shall extend to the ground surface seal, except where a road box meeting the requirements of Rule 10.0 of this Appendix is used.

8.3 Ground Surface Seal: All monitoring wells shall be constructed with a continuous pour concrete ground surface seal. To avoid frost heaving and to anchor the well, the ground surface seal shall extend to a minimum of 40 inches below the land surface, unless the well meets one of the requirements of the exemption described in Rule 8.4 of this Appendix. The ground surface seal shall be flared such that the diameter at the top is greater than the diameter at the bottom. The top of the ground surface seal shall be sloped away from the well casing and shall be imprinted with the designation of the monitoring well.

8.4 Exemption from 40 Inch Ground Surface Seal Requirement: As stated in Rule 8.3 of this Appendix, the ground surface seal shall extend at least 40 inches down the hole from the land surface. Exemptions from this rule are limited to the following circumstances: 1) where the seal would interfere with proper placement or functioning of the well screen; and 2) where a road box is used and sand is placed inside and directly below the road box in such a way as to ensure that any seepage into the road box drains away from the well.

9.0 Protective Cover Pipe: The protective pipe shall consist of a minimum 4 inch diameter metal casing with locking cap. The protective pipe shall extend from the bottom of the ground surface seal to a minimum of 24 inches above the land surface. There shall be no more than 4 inches between the top of the well casing and the top of the protective pipe. The monitoring well designation shall be indicated clearly on the protective cover pipe. A gas vent and a drain hole shall be installed. A high visibility guard post to prevent destruction of the well may be required. The Director may request additional protective devices as necessary.

10.0 Road Box: Road boxes are acceptable in locations where protective cover pipes are not suitable. All road boxes shall be secured and water tight and prevent easy access to the well. The well shall be fitted with a locking, water tight cap. The ground surface seal for the road box shall be competent such that vehicle traffic will not cause it to fail. The annular space seal shall extend upward to within one foot of the ground surface seal. One or two feet of permeable material may be emplaced between the ground surface seal and the annular space seal in order to allow for the drainage of runoff which may leak into the road box from the ground surface.

11.0 Well Development: Development of all monitoring wells shall be performed no earlier than 48 hours after completion and before the initial water quality samples are taken. The goal of well development is to produce water free of fine sand, coarser material, drill cuttings, and drilling fluids. The formation shall be allowed to stabilize for at least 24 hours before groundwater sampling.

12.0 Innovative Well Installation: Innovative wells, including but not limited to Microwells or Geoprobes, that are small-diameter and are non-destructive to the formation, and which are capable of providing samples representative of groundwater, need not meet the construction requirements set forth in Rules 4.0 through 11.0 of this Appendix.

13.0 Monitoring Well and Piezometer Abandonment:

13.1 General:

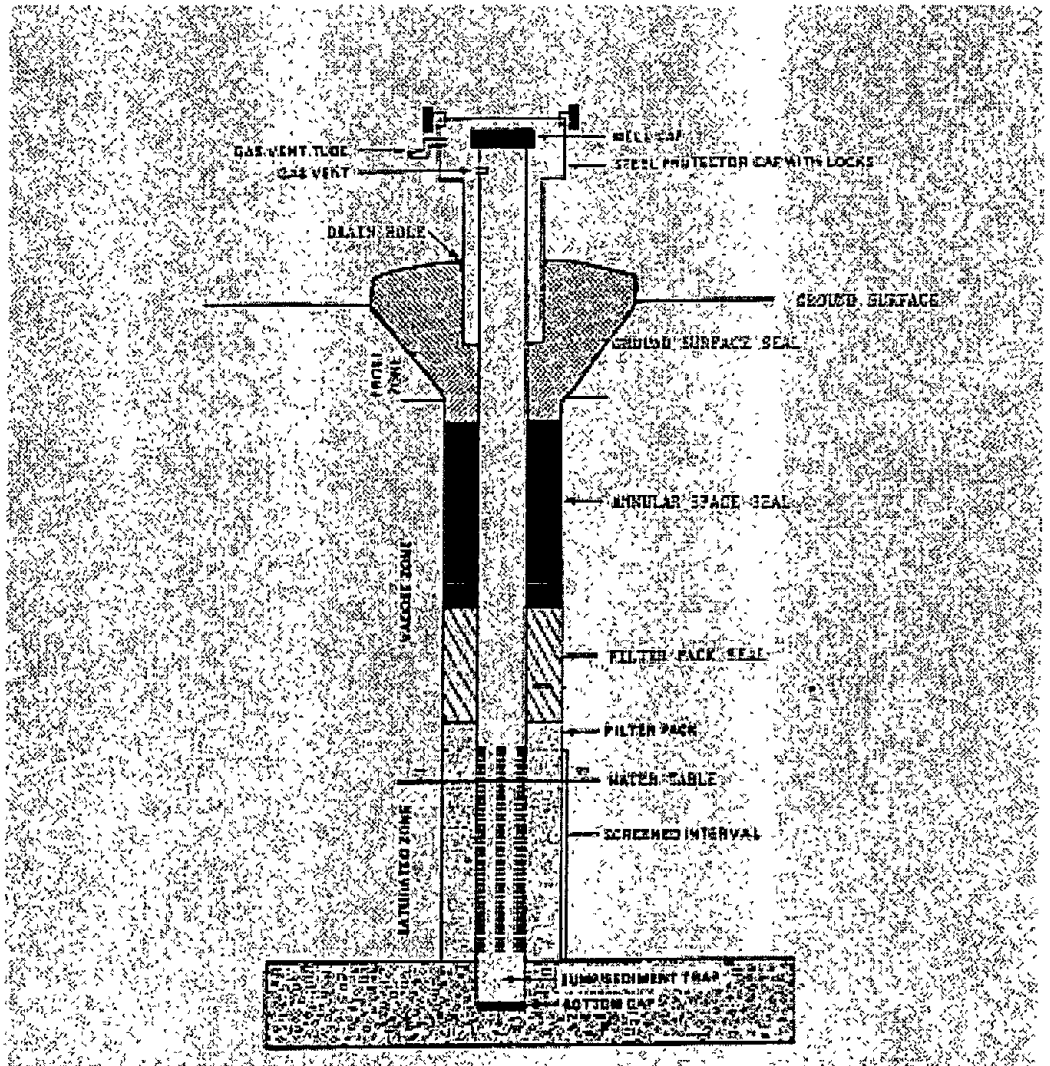
(a): All monitoring wells and applicable piezometers as described in Rule 1.0 of this Appendix that are no longer used to gather information on geologic or groundwater properties shall be abandoned pursuant to the provisions of Rule 13.2 of this Appendix. Well abandonment shall take place within 60 days after its use has been terminated, unless a written exemption is received from the Director for continued use.

(b) Innovative wells: Innovative wells as described in Rule 12.0 of this Appendix shall be abandoned at the end of use in order to remove the conduit to groundwater. Abandonment of innovative wells shall consist of removal of the well and grouting of the borehole. Innovative wells are exempted from the abandonment procedures described in Rule 13.2 of this Appendix.

13.2 Abandonment Procedures: The well shall be inspected from the land surface through the entire depth of the well before it is sealed to ensure against the presence of any obstructions that will interfere with sealing operations.

(a) Wells constructed with an impermeable annular seal shall be abandoned by cutting off the casing a minimum of 4 feet below land surface. The remaining casing shall be completely filled with a neat cement grout or bentonite-cement grout. The remaining hole volume shall be backfilled with natural material, with the following exception: where backfilling with natural material would result in a grout plug less than 4 feet long, the hole shall be filled to approximately one foot from the ground surface with the neat cement grout or bentonite-cement grout.

(b) Wells not known to be constructed with an impermeable annular seal shall be abandoned by completely removing the well casing and sealing with neat cement or bentonite-cement grout to approximately one foot from the ground surface. If the casing cannot be removed during the abandonment of a well, the casing shall be thoroughly ripped or perforated from top to bottom. except that perforations will not be required over intervals of the well that are sealed with cement. The screened portion of the well and the annular space between the casing and the drillhole wall shall be effectively and completely filled with cement or bentonite-cement grout applied under pressure.



CROSS-SECTION OF TYPICAL MONITORING WELL

Adapted from U.S. EPA, 1986, RCRA Groundwater Monitoring Technical Enforcement Guidance Document

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUND WATER SAMPLES FROM MONITORING WELLS

July 30, 1996
Revision 2

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUND WATER SAMPLES FROM MONITORING WELLS

I. SCOPE & APPLICATION

This standard operating procedure (SOP) provides a general framework for collecting ground water samples that are indicative of mobile organic and inorganic loads at ambient flow conditions (both the dissolved fraction and the fraction associated with mobile particulates). The SOP emphasizes the need to minimize stress by low water-level drawdowns, and low pumping rates (usually less than 1 liter/min) in order to collect samples with minimal alterations to water chemistry. This SOP is aimed primarily at sampling monitoring wells that can accept a submersible pump and have a screen, or open interval length of 10 feet or less (this is the most common situation). However, this procedure is flexible and can be used in a variety of well construction and ground-water yield situations. Samples thus obtained are suitable for analyses of ground water contaminants (volatile and semi-volatile organic analytes, pesticides, PCBs, metals and other inorganics), or other naturally occurring analytes.

This procedure does not address the collection of samples from wells containing light or dense non-aqueous phase liquids (LNAPLs and DNAPLs). For this the reader may wish to check: Cohen, R.M. and J.W. Mercer, 1993, DNAPL Site Evaluation; C.K. Smoley (CRC Press), Boca. Raton, Florida and U.S. Environmental Protection Agency, 1992, RCRA Ground-Water Monitoring: Draft Technical Guidance; Washington, DC (EPA/530-R-93-001).

The screen, or open interval of the monitoring well should be optimally located (both laterally and vertically) to intercept existing contaminant plume(s) or along flowpaths of potential contaminant releases. It is presumed that the analytes of interest move (or potentially move) primarily through the more permeable zones within the screen, or open interval.

Use of trademark names does not imply endorsement by U.S.EPA but is intended only to assist in identification of a specific type of device.

II. EQUIPMENT

A. Extraction device

Adjustable rate, submersible pumps are preferred (for example, centrifugal or bladder pump constructed of stainless steel or Teflon).

Adjustable rate, peristaltic pumps (suction) may be used with caution. Note that EPA guidance states: "Suction pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" (EPA/540/P-87/001, 1987, page 8.5-11).

The use of inertial pumps is discouraged. These devices frequently cause greater disturbance during purging and sampling and are less easily controlled than the pumps listed above. This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

B. Tubing

Teflon or Teflon lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics.

PVC, polypropylene or polyethylene tubing may be used when collecting samples for inorganics analyses. However, these materials should be used with caution when sampling for organics. If these materials are used, the equipment blank (which includes the tubing) data must show that these materials do not add contaminants to the sample.

Stainless steel tubing may be used when sampling for VOCs, SVOCs, pesticides, and PCBs. However, it should be used with caution when sampling for metals.

The use of 1/4 inch or 3/8 inch (inner diameter) tubing is preferred. This will help ensure the tubing remains liquid filled when operating at very low pumping rates.

Pharmaceutical grade (Pharmed) tubing should be used for the section around the rotor head of a peristaltic pump, to minimize gaseous diffusion.

C. Water level measuring device(s), capable of measuring to 0.01 foot accuracy (electronic "tape", pressure transducer). Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use

III. PRELIMINARY SITE ACTIVITIES

Check well for security damage or evidence of tampering, record pertinent observations.

Lay out sheet of clean polyethylene for monitoring and sampling equipment.

Remove well cap and immediately measure VOCs at the rim of the well with a PID or FID instrument and record the reading in the field logbook.

If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook.

A synoptic water level measurement round should be performed (in the shortest possible time) before any purging and sampling activities begin. It is recommended that water level depth (to 0.01 ft.) and total well depth (to 0.1 ft.) be measured the day before, in order to allow for re-settlement of any particulates in the water column. If measurement of total well depth is not made the day before, it should not be measured until after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe are usually not needed unless analytical data or field head space information signal a worsening situation. Note: procedures for collection of LNAPL and DNAPL samples are not addressed in this SOP.

IV. PURGING AND SAMPLING PROCEDURE

Sampling wells in order of increasing chemical concentrations (known or anticipated) is preferred.

1. Install Pump

Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the midpoint of the zone to be sampled. The Sampling and Analysis Plan should specify the sampling depth, or provide criteria for selection of intake depth for each well (see Section I). If possible keep the pump intake at least two

3b. Subsequent Low Stress Sampling Events

After synoptic water level measurement round, check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). Perform purging operations as above.

4. Monitor Indicator Field Parameters

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, Eh, DO) every three to five minutes (or less frequently, if appropriate). Note: during the early phase of purging emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings, taken at three (3) to five (5) minute intervals, are within the following limits:

turbidity (10% for values greater than 1 NTU),
DO (10%),
specific conductance (3%),
temperature (3%),
pH (± 0.1 unit),
ORP/Eh (± 10 millivolts).

All measurements, except turbidity, must be obtained using a flow-through-cell. Transparent flow-through-cells are preferred, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values measured within the cell and may also cause an underestimation of turbidity values measured after the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities.

The flow-through-cell must be designed in a way that prevents air bubble entrapment in the cell. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must be submerged in water at all times. If two flow-through-cells are used in series, the one containing the dissolved oxygen probe should come first (this parameter is most susceptible to error if air leaks into the system).

Label each sample as collected. Samples requiring cooling (volatile organics, cyanide, etc.) will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

6. Post Sampling Activities

If recording pressure transducer is used, remeasure water level with tape.

After collection of the samples, the pump tubing may either be dedicated to the well for resampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. Note: measurement of total well depth is optional after the initial low stress sampling event. However, it is recommended if the well has a "silting" problem or if confirmation of well identity is needed.

Secure the well.

V. DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well and following sampling of each subsequent well. Pumps will not be removed between purging and sampling operations. The pump and tubing (including support cable and electrical wires which are in contact with the well) will be decontaminated by one of the procedures listed below.

Procedure 1

The decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump or the pump can be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and isopropyl alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is

may not exceed 20 samples). Trip blanks are required for the VOC samples at a frequency of one set per VOC sample cooler.

Field duplicate.

Matrix spike.

Matrix spike duplicate.

Equipment blank.

Trip blank (VOCs).

Temperature blank (one per sample cooler).

Equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank will only include the pump in subsequent sampling rounds.

Collect samples in order from wells with lowest contaminant concentration to highest concentration. Collect equipment blanks after sampling from contaminated wells and not after background wells.

Field duplicates are collected to determine precision of sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

If split samples are to be collected, collect split for each analyte group in consecutive order (VOC original, VOC split, etc.). Split sample should be as identical as possible to original sample.

All monitoring instrumentation shall be operated in accordance with EPA analytical methods and manufacturer's operating instructions. EPA analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846 with exception of Eh, for which the manufacturer's instructions are to be followed. Instruments shall be calibrated at the beginning of each day. If a measurement falls outside the calibration range, the instrument should be re-calibrated so that all measurements fall within the calibration range. At the end of each day, check calibration to verify that instruments remained in calibration. Temperature measuring equipment, thermometers and thermistors, need not be calibrated to the above frequency. They should be checked for accuracy prior to field use according to EPA Methods and the manufacturer's instructions.

EXAMPLE (Minimum Requirements)

Page____of____

Well PURGING-FIELD WATER QUALITY MEASUREMENTS FORM

Location (Site/Facility Name)_____ Depth to _____/_____ of screen
Well Number_____ Date_____ (below MP) top bottom
Field Personnel_____ Pump Intake at (ft. below MP)_____
Sampling Organization_____ Purging Device; (pump type)_____
Identify MP

Clock Time 24 HR	Water Depth below MP ft	Pump Dial[1] 	Purge Rate ml/min	Cum. Volume Purged liters	Temp. °C	Spec. Cond.[2] µS/cm	pH 	ORP/ Eh[3] mv	DO mg/L	Turb-idity NTU	Comments

1. Pump dial setting (for example: hertz, cycles/min, etc).
2. µSiemens per cm(same as µmhos/cm)at 25°C.
3. Oxidation reduction potential (stand in for Eh).

HEALTH AND SAFETY PLAN

Health and Safety Plan
Former Melville North Landfill

Groundwater Monitoring

Portsmouth, Rhode Island

Engineering Field Activity Northeast
Naval Facilities Engineering Command

Contract No. N62472-94-D-0888
Contract Task Order 0842

May 2003

Health and Safety Plan
Former Melville North Landfill

Groundwater Monitoring

Portsmouth, Rhode Island

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION - NAVY (CLEAN) CONTRACT

Submitted to:
Engineering Field Activity Northeast
Environmental Branch, Code 1812BJH
Naval Facilities Engineering Command
10 Industrial Highway, Mail Stop No. 82
Lester, Pennsylvania 19113-2090

Submitted by:
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Contract No. N62472-94-D-0888
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1.0 INTRODUCTION

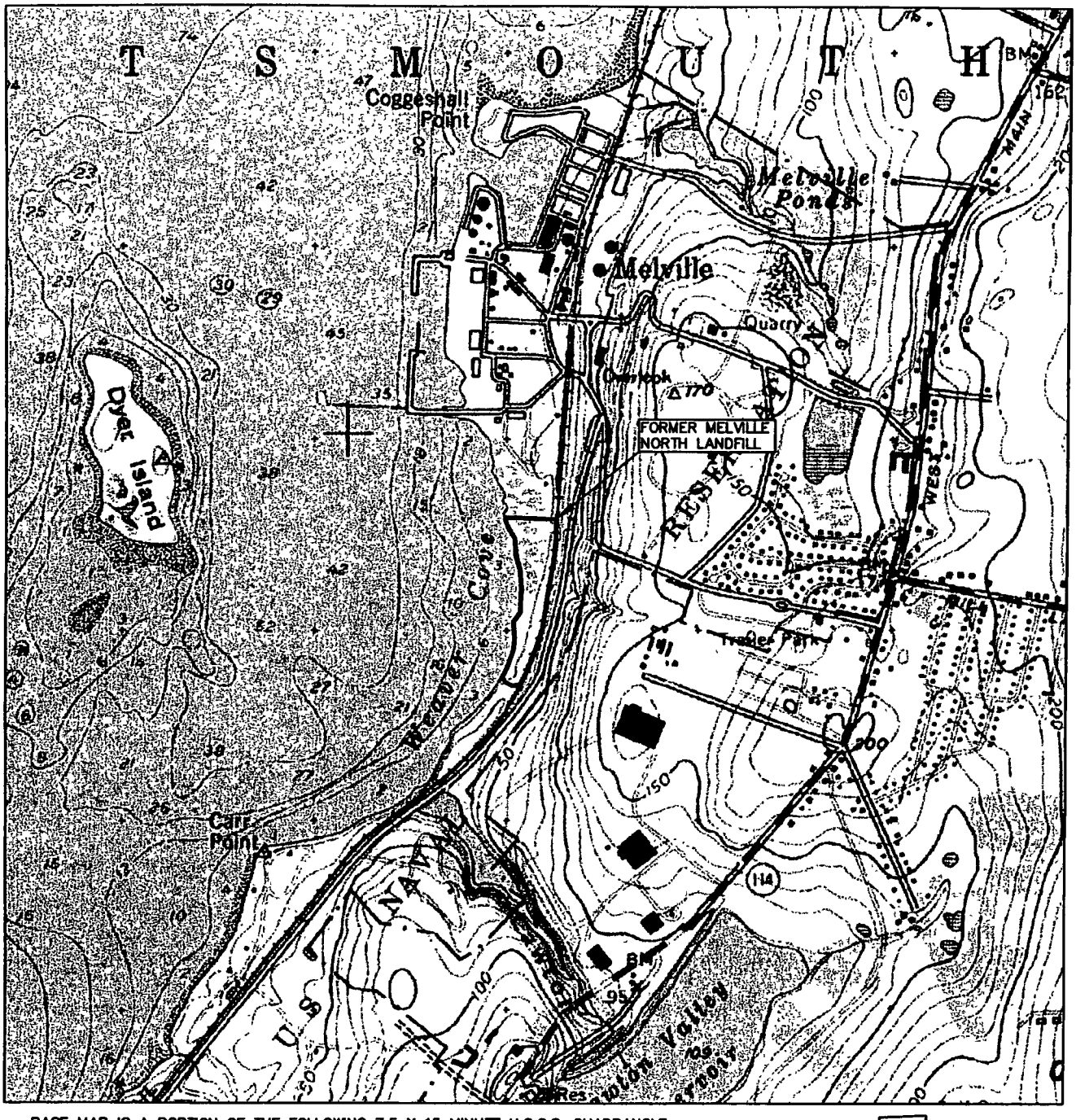
This Health and Safety Plan (HASP) was developed to provide safe working practices and procedures for Tetra Tech NUS, Inc and subcontractor personnel engaged in post-removal action well installation and sampling activities to be conducted at the former Melville North Landfill located in Portsmouth, Rhode Island (Figures 1 and 2). This HASP is designed to be used in conjunction with the Tetra Tech NUS, Inc. (TtNUS) Health and Safety Guidance Manual. The TtNUS Health and Safety Guidance Manual provides supporting information pertaining to procedures detailed in the HASP as well as TtNUS standard operating procedures.

The Melville North Landfill underwent a large removal action in 1997-2000, during which all the fill and contaminated soils above the groundwater table was removed from the site Clean fill was brought in to restore the site to approximate pre-construction grade. The work to be performed under this HASP is to conduct limited soil and groundwater monitoring to determine effectiveness of this removal action.

This HASP was developed in accordance with the requirements established by OSHA 29 CFR 1910.120 "Hazardous Waste Operations and Emergency Response" (HAZWOPER) and sections of 29 CFR 1926 "Safety and Health Regulations For Construction." The information provided in this plan has been obtained from the Tetra Tech NUS, Inc. Health and Safety Program policies and procedures.

This HASP was developed using information gathered from existing file information which represents the most current information regarding known or suspected chemical contaminants, and potential physical hazards associated with the proposed work and the history of the site. This HASP will be modified, as necessary, if new information becomes available. All changes to the HASP will be made with the approval of the Tetra Tech NUS, Inc. Site Safety Officer (SSO) and the CLEAN Health and Safety Manager (HSM). Requests for modifications to the HASP will be directed to the SSO, who will determine whether or not to make changes. The SSO will notify the Project Manager (PM), who will then notify all affected personnel of the changes.

Subcontractors performing work onsite will be required to comply with the minimum requirements of this plan. Each subcontractor employee performing work at the site must complete a copy of the HASP review form (Figure 8-2) indicating that the individual has read, understands, and will comply with the HASP.



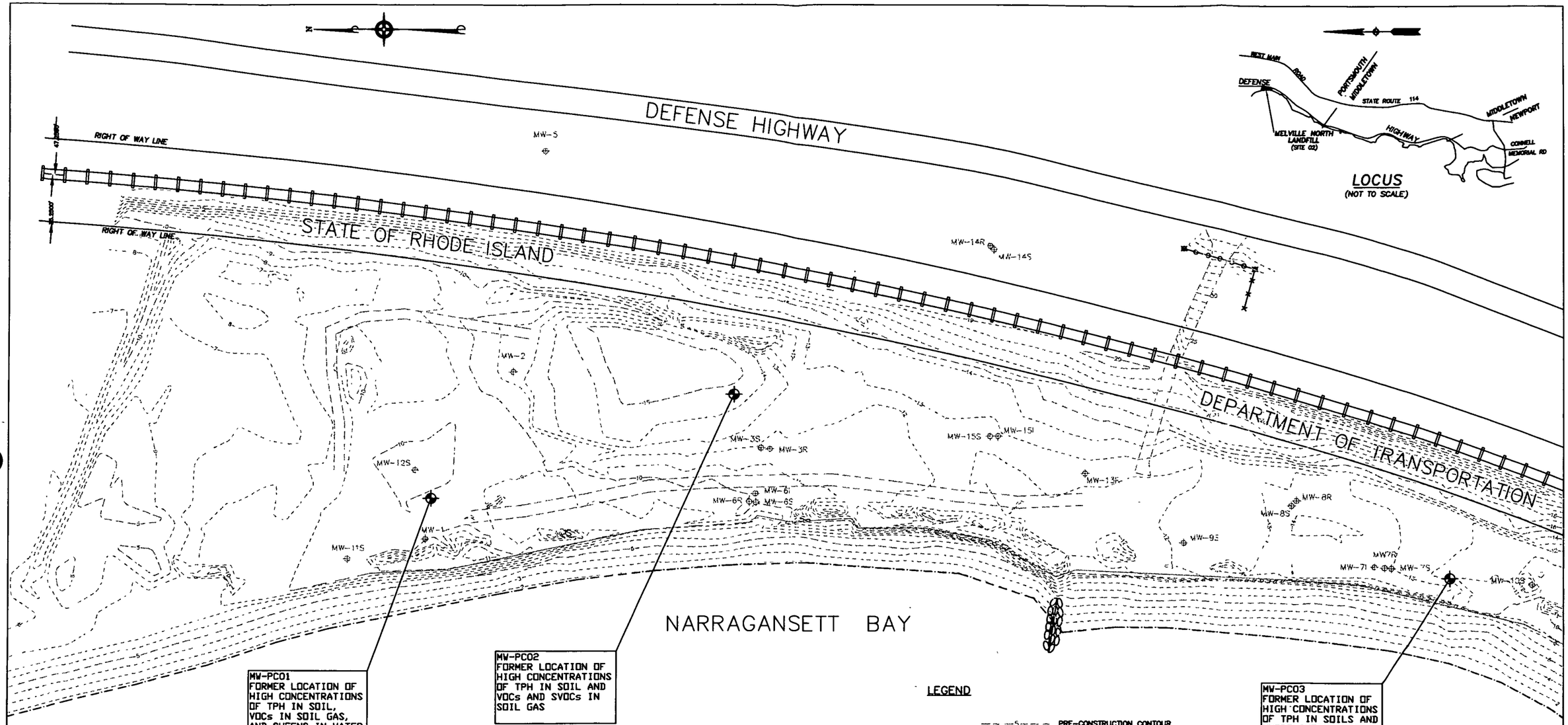
BASE MAP IS A PORTION OF THE FOLLOWING 7.5 X 15 MINUTE U.S.G.S. QUADRANGLE:
PRUDENCE ISLAND, RHODE ISLAND, 1955, PHOTOREVISED 1970 AND 1975

GRAPHIC SCALE
0 0.5 MILE 1 MILE

QUADRANGLE LOCATION

SITE LOCUS		FIGURE 1-1	
FORMER MELVILLE NORTH LANDFILL			
PORTSMOUTH, RHODE ISLAND			
DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	S. PARKER	DATE:	MARCH 6, 2003
SCALE:	AS NOTED	ACAD NAME:	DWG\5152\0481\FIG_1-1.DWG

TETRA TECH NUS, INC.
55 Jonspin Road Wilmington, MA 01887
(978)658-7899



REFERENCE PLANS:

1. NAVAL COMPLEX, NEWPORT, R.I., MELVILLE (NORTH), EXISTING CONDITIONS MAP, BY NAVAL FACILITIES ENGINEERING COMMAND, DWG. NO. 994, 207.
2. PLAT SHOWING LAND IN CITY OF NEWPORT & TOWNS OF MIDDLETOWN & PORTSMOUTH, ACQUIRED FOR RAILROAD PURPOSES ON BEHALF OF THE STATE OF RHODE ISLAND & PROVIDENCE PLANTATIONS, BY THE DIRECTOR OF TRANSPORTATION, RAILROAD PLAT NO. 1.
3. BASE PLAN ENTITLED "SITE 02, MELVILLE NORTH LANDFILL, SITE MAP" PREPARED FOR NAVAL EDUCATION TRAINING CENTER, NEWPORT, RHODE ISLAND, SCALE: 1"=60', DWG.NO. 2, PROJ.NO. 6760-N81, DATED: 5/29/91, PREPARED BY: SAI SURVEYING, CO.

NOTES:

1. ALL COORDINATES SHOWN HEREON ARE RHODE ISLAND GRID COORDINATES, NORTH AMERICAN DATUM OF 1927, PER REFERENCE PLAN.
2. ELEVATION DATUM: MEAN LOW WATER, U.S. NAVY.
3. THE CONTOUR INTERVAL IS ONE (1) FEET.
4. CONTROL POINTS 1 & 2 ARE LOCATED ALONG RAILROAD BASELINE, EACH FOUND APPROXIMATELY 1 FOOT BELOW SURFACE.

PROPOSED POST-CLOSURE MONITORING WELLS			
FORMER MELVILLE NORTH LANDFILL			
PORTSMOUTH, RHODE ISLAND			
DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	S. PARKER	DATE:	MARCH 6, 2003
SCALE:	AS NOTED	FILE NO.:	DWG\5152\0481\FIG_1-2.DWG

FIGURE 1-2

TETRA TECH NUS, INC.
55 Jonspin Road Wilmington, MA 01887
(978)658-7899

1.1 KEY PROJECT PERSONNEL AND ORGANIZATION

This section defines responsibility for site safety and health for TtNUS and subcontractor employees engaged in on-site activities. The specific project personnel (Project Manager, Field Operations Leader) assigned to these positions have primary responsibility for implementing on-site health and safety requirements and the HSM and the SSO will be the primary points of contact for any questions regarding the safety and health procedures and the selected control measures that are to be implemented for on-site activities.

- The TtNUS Project Manager (PM) is responsible for the overall direction and implementation of health and safety for this project.

- The TtNUS HSM is responsible for developing this HASP in accordance with applicable OSHA regulations. Specific responsibilities include.

  - providing information regarding site contaminants and physical hazards associated with the site
  - establishing air monitoring and decontamination procedures
  - selecting personal protective equipment
  - determining emergency response procedures and emergency contacts
  - stipulating training requirements and reviewing appropriate training and medical surveillance certificates
  - providing standard work practices to minimize potential injuries and exposures associated with hazardous work

- The TtNUS Field Operations Leader (FOL) is responsible for implementation of this HASP with the assistance of an appointed SSO. The FOL manages all field activities, executes elements of the Work Plan and enforces safety procedures, as applicable to the HASP.

- The SSO supports site activities by advising the FOL on all aspects of health and safety on-site. These duties may include:

  - coordinating all health and safety activities with the FOL
  - selecting, applying, inspecting and maintaining personal protective equipment
  - establishing work zones and control points
  - implementing air monitoring procedures for on-site activities

- verifying training and medical status of on-site personnel
- implementing hazard communication, respiratory protection and other associated safety and health programs
- coordinating emergency services
- providing site specific training to all on-site personnel

Compliance to the requirements established in this HASP is monitored by the SSO and coordinated through the TtNUS HSM.

1.2 SITE INFORMATION AND PERSONNEL ASSIGNMENTS

Site Name:	Former Melville North Landfill
Address:	Defense Highway
	Portsmouth, Rhode Island
Effective Date:	May 2003 through August 2004

Purpose of Site Work: Conduct soil and groundwater monitoring at a former landfill site which has undergone a major removal action.

Project Team:

Tetra Tech NUS, Inc. Personnel:	**Discipline/Tasks Assigned:**
Stephen S. Parker	Project Manager (PM)
Kayleen Jalkut	Field Operations Leader (FOL)
TBD	Field Team Personnel
Kayleen Jalkut	Site Safety Officer (SSO)
Janet Pillion	Wilmington Health and Safety Officer (HSO)
Matt Soltis	CLEAN Health and Safety Manager (HSM)

Non-TtNUS Personnel

Surveying Subcontractor
Drilling Subcontractor
IDW Subcontractor

Prepared by: Stephen S. Parker

2.0 EMERGENCY ACTION PLAN

2.1 INTRODUCTION

This section has been developed as part of a preplanning effort to direct and guide field personnel in the event of an emergency. All site activities will be coordinated with Local Fire Protection and Emergency Services prior to commencement. In the event of on-site emergencies, site personnel will be evacuated to a safe place of refuge and the appropriate emergency response agencies will be notified. Since a majority of foreseeable emergency situations will require assistance from outside emergency responders, TtNUS and subcontractor personnel will not provide emergency response support beyond the capabilities of on-site response. The emergency response agencies listed in this plan are capable of providing the most effective response, and as such, will be designated as the primary responders. These agencies are located within a reasonable distance from the area of operations, which ensures adequate emergency response time. This Emergency Action Plan, therefore, conforms to the requirements of OSHA Standard 29 CFR 1910.38(a), as designated in OSHA 29 CFR 1910.120(l)(1)(ii).

TtNUS will, through necessary services, provide the following response measures:

- Incipient stage fire fighting support and prevention
- Incipient spill control and containment measures and prevention
- Removal of personnel from emergency situations
- Initial medical support for injuries or illnesses requiring only first-aid level support
- Site control and security measures, as necessary

2.2 PRE-EMERGENCY PLANNING

Through the initial hazard/risk assessment effort, injuries or illnesses resulting from exposure to chemical or physical hazards or fire are the most probable emergencies that could be encountered during site activities.

To minimize and eliminate these potential emergency situations, pre-emergency planning activities associated with this project include the following (which are the responsibility of the SSO and/or the FOL):

- Coordinating with local Emergency Response personnel in order to ensure that TtNUS emergency action activities are compatible with existing emergency response procedures.

- Establishing and maintaining information at the project staging area (support zone) for easy access in the event of an emergency. This information will include the following:

  - Chemical Inventory (used on-site), with Material Safety Data Sheets.
  - On-site personnel medical records (Medical Data Sheets).
  - A log book or sign in logsheet identifying personnel on site each day.

It will be the responsibility of the TtNUS FOL to ensure specific information is available and present at the site, including:

- The chain of command for emergency action.

- Potential hazards and control measures associated with planned activities at the site, and providing methods for early recognition and prevention when possible.

2.3 EMERGENCY RECOGNITION AND PREVENTION

2.3.1 Recognition

Foreseeable emergency situations that may be encountered during site activities will generally be recognizable by visual observation. Visual observation is primarily relevant for physical hazards that may be associated with the proposed scope of work. Visual observation will also play a role in detecting some chemical exposures. To adequately recognize exposures to site contaminants, site personnel must have a clear knowledge of the signs and symptoms of exposure associated with the site contaminants. This information is provided in Table 6-1 of this HASP. Potential site hazards, the activities that they have been associated with, and the recommended control methods are discussed in detail in Section 5.0 and 6.0 of this HASP. Additionally, early recognition of emergency situations will be supported by daily site surveys to eliminate any situation considered predisposed to an emergency. The FOL and the SSO will be responsible for performing site surveys, which will be conducted at least once a week during the initiation of this effort and will be documented in the Health and Safety Logbook. The above actions provide early recognition for potential emergency situations. However, should an incident occur, TtNUS will take measures to control these situations. If the FOL and the SSO determine that an incident has progressed to a serious emergency situation, TtNUS will withdraw and notify the appropriate response agencies listed in Table 2-1.

2.3.2 Prevention

TtNUS and subcontractor personnel will minimize the potential for emergencies by following the Health and Safety Guidance Manual and complying with the HASP and applicable OSHA regulations.

2.4 SAFE DISTANCES AND PLACES OF REFUGE

In the event that the site must be evacuated, all personnel will immediately stop activities and report to the designated safe place of refuge. Safe places of refuge will be identified prior to the commencement of site activities and will be conveyed to personnel as part of the safety meeting conducted each morning. Whenever possible, the safe place of refuge will also serve as the telephone communications point for that area. During an evacuation, personnel will remain at the refuge location until directed otherwise by the TtNUS FOL or SSO. The FOL or the SSO will take a head count at this location to account for and to confirm the location of all site personnel. Emergency response personnel will be immediately notified of any unaccounted personnel.

2.5 EVACUATION ROUTES AND PROCEDURES

An evacuation will occur whenever the health, safety or welfare of site workers is compromised. Specific examples of conditions that may initiate an evacuation include, but are not limited to the following: severe weather conditions; the occurrence of a fire or explosion; readings on monitoring instrumentation indicate levels of contamination that are greater than instituted action levels; or personnel show signs or symptoms of overexposure to potential site contaminants. In the event of an evacuation, personnel will proceed immediately to the designated place of refuge unless doing so would further jeopardize the welfare of workers In such an event, personnel will proceed to a designated alternate location and remain until further notification from the TtNUS FOL. Evacuation procedures will be discussed before the initiation of any work at the site.

Evacuation routes from the site and safe places of refuge are dependent upon the location at which work is being performed and the circumstances under which an evacuation is required. Additionally, site location and meteorological conditions (i.e., wind speed and direction) may dictate evacuation routes.

As a result, assembly points will be selected and communicated to the workers relative to the site location where work is being performed.

TABLE 2-1
EMERGENCY REFERENCE
HEALTH AND SAFETY PLAN
FORMER MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND

CONTACT	PHONE NUMBER
EMERGENCY (Fire/Ambulance/Police) OR Portsmouth Police Dept Portsmouth Fire Dept	911 (401) 683-1936 (401) 683-1200
Newport Hospital Friendship St. Newport, RI	(401) 846-6400
Chemtrec National Response Center	(800) 424-9300 (800) 424-8802
Project Manager: Stephen S. Parker	978) 658-7899
CLEAN Health and Safety Manager. Matt Soltis	(412) 921-7090
Health and Safety Officer: Janet Pillion	(978) 658-7899

2.6 DECONTAMINATION PROCEDURES/EMERGENCY MEDICAL TREATMENT

During an evacuation, decontamination procedures will be performed only if doing so does not further jeopardize the welfare of site workers. However, it is unlikely that an evacuation would occur which would require workers to evacuate the site without first performing decontamination procedures.

2.7 EMERGENCY ALERTING AND ACTION/RESPONSE PROCEDURES

At each site, TtNUS personnel will be working in proximity to each other. As a result, hand signals, voice commands and air horns will be sufficient to alert site personnel of an emergency. If teams will be working simultaneously as part of this project, two-way radios will be used to communicate between teams of workers.

If an emergency occurs, the following steps are to be taken:

- Initiate an evacuation by hand signals, voice commands, air horn or two-way radios. Report to the designated refuge point.

- Describe to the FOL (who will serve as the Incident Coordinator) what has occurred and as many details as possible. Once all personnel are evacuated, appropriate response procedures will be enacted to control the situation.

In the event that site personnel cannot control the incident through offensive and defensive measures, the FOL and SSO will enact the emergency notification procedures to secure additional assistance in the following manner:

- Call 911 or other emergency contacts (Table 2-1) and report the emergency. Give the operator the location of the emergency, the type of emergency, the number of people injured, and a brief description of what occurred. Stay on the phone and follow the instructions given by the operator. The operator will then notify and dispatch the proper emergency response agencies.

2.8 PPE AND EMERGENCY EQUIPMENT

A first-aid kit, eye wash units and fire extinguishers (strategically placed) will be maintained on-site and shall be immediately available for use in the event of an emergency.

2.9 EMERGENCY CONTACTS

Prior to performing work onsite, all personnel will be thoroughly briefed on the emergency procedures that are to be followed in the event of an accident. Table 2-1 provides a list of emergency contacts and their associated telephone numbers. This table must be posted on-site where it is readily available to all site personnel

2.10 EMERGENCY ROUTE TO HOSPITAL

The Naval Ambulatory Care Center (Naval Hospital) is less than 100 yards to the northeast of the site. Medical emergencies shall be taken directly to this ambulatory care center, and then transferred to Newport Hospital. All other non emergency medical treatment should be taken to Newport Hospital, approximately 3 miles from the site.

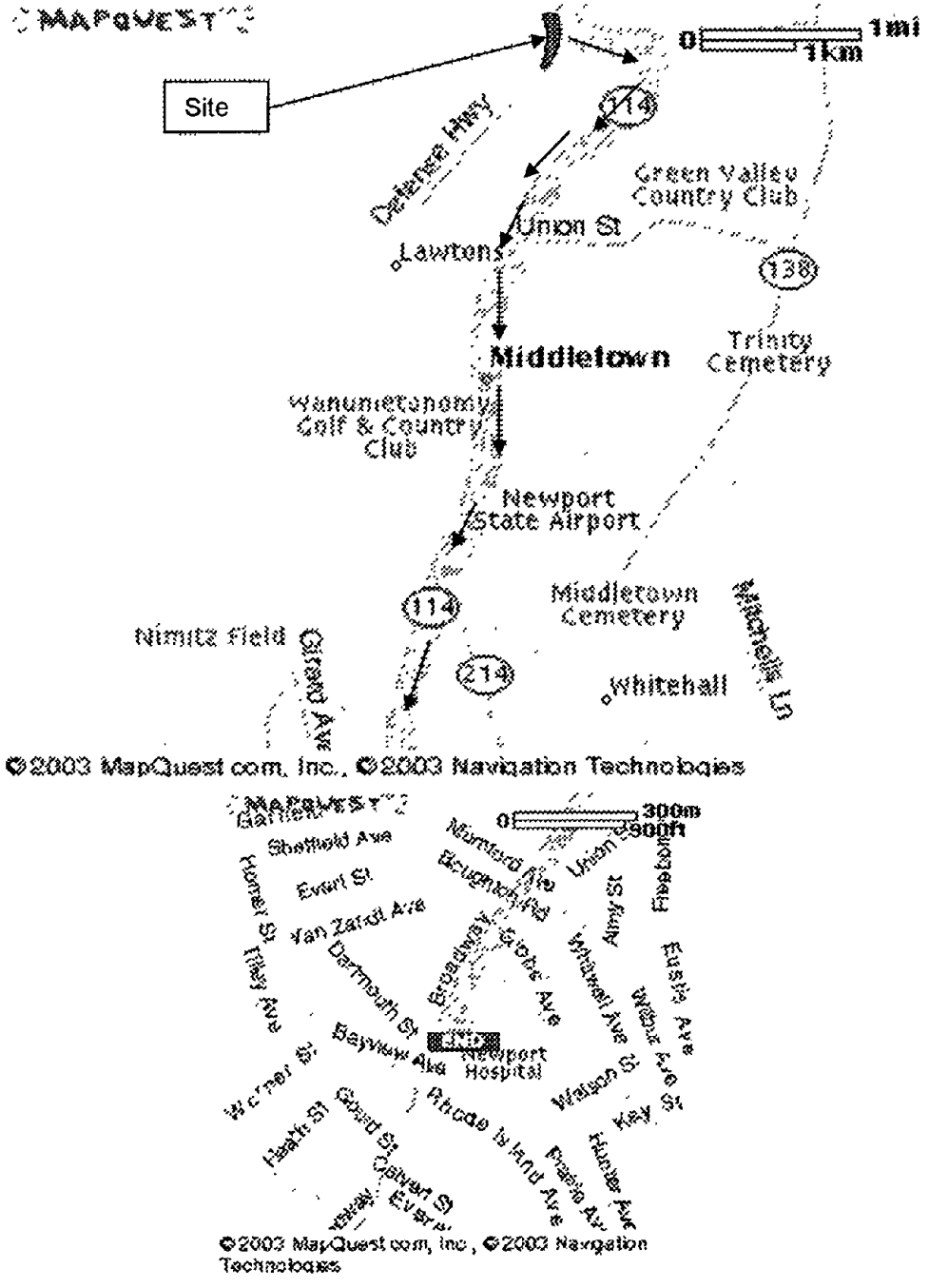
Directions to Newport Hospital:

Friendship Street
Newport, RI
(401) 846-6400

REFER TO FIGURE 2-1

Leave Site through Gate, turn **left** on Defense Highway
Approx **0.25 mi**, Turn **right** on Melville Road
Approx **0.6 mi**, turn **right** on Route 114
Approx **4 mi**, Route 114 turns right. Leave Route 114 by going **straight** onto Broadway.
Approx **1 mi**, turn **left** on Friendship St. Hospital is on Corner

FIGURE 2-1
HOSPITAL ROUTE MAP
NEWPORT HOSPITAL, FRIENDSHIP STREET
HEALTH AND SAFETY PLAN
FORMER MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND



3.0 SITE BACKGROUND

3.1 SITE INFORMATION

The Melville North Landfill site is located in the northwest portion of Aquidneck Island on the shoreline of Narragansett Bay in the Town of Portsmouth. The site is approximately 10 acres in size and was used as a landfill from World War II until 1955. The site was excessed from the Naval Station-Newport to the State of Rhode Island in September 1993, and was sold to Melville Marine Industries six months later

Access to the Melville North Landfill site is gained from the east via Defense Highway. The site is bounded to the west by Narragansett Bay, to the east by the Penn Central railroad tracks and Defense Highway (also known as Burma Rd), to the north by vegetated wetlands, and to the south by a wooded upland area. The topography of the site is relatively flat with elevation drops between 5 and 10 feet along the shoreline and an increase in elevation between 5 and 10 feet along Defense Highway.

The landfill reportedly received a variety of waste materials from World War II until 1955. These wastes include spent acids, various waste oils, solvents, waste paints, and possibly polychlorinated biphenyls (PCBs). Initial inspections of the site also revealed mounds of oil-soaked soil and surface areas that were covered with oil and oil sludge. It was reported that the mounds of oil-soaked soil came from disposal of the oil sludge material generated while cleaning fuel supply tanks at the nearby tank farms, or from cleanup operations of various oil spills.

The Melville North Landfill received wastes including spent acids, waste paints, solvents, waste oils (diesel, fuel, lube), and PCBs. The waste quantity disposed of in the landfill is unknown. Pre-removal action inspections of the site, revealed areas covered with oil and oil sludge scattered throughout the site. Mounds of oil-soaked soil appeared to have been trucked to and deposited of at the Site. These oil-contaminated mounds could have been the oil sludge materials obtained from the tank farms during tank cleaning operations, or the result of cleanup operations following oil spills.

A series of removal actions have been conducted at the site. The first was performed in 1993 to remove soil piles found to contain oil. These soils were removed from the Site and disposed of at a licensed facility. The second removal action was conducted in 1996 to address additional soils with oil contamination and elevated concentrations of metals. Following the second removal action, a Site Investigation was conducted under RIDEM remediation regulations to, in part, determine a final remedy for the Site.

A third removal action was carried out as a final remedy for the Site by Foster Wheeler Environmental Corporation (FWENC) at the Site from April 15, 1999 to May 3, 2000. Soil excavation was conducted across the entire area that was recorded to have received waste. Field screening, laboratory confirmation sampling, visual inspection, and the presence of large quantities of debris were used during the soil excavation activities to delineate the vertical and horizontal limits of the excavation area. A total of 73,001 cubic yards of soil and debris was removed by the beginning of 2000. An additional 4000 tons of material was excavated from the southern part of the landfill, and this effort was conducted in April 2000.

The current action has been planned to determine if any contaminants remain in the groundwater at the site following these removal actions that are in excess of regulatory standards

4.0 SCOPE OF WORK

This section discusses the activities that are to be performed at the site. Table 5-1 of this HASP provides information related to the tasks that are to be performed as part of the scope of work. The planned activities are presented in detail in the Work Plan developed for this project. If new tasks are to be performed at the site, Table 5-1 will be modified accordingly. If tasks other than those described below are performed at the site, this section will be modified accordingly.

The scope of work for this project is to conduct post-removal monitoring at the former Melville North Landfill. The investigative activities include:

1. Install groundwater monitoring wells.

2 Evaluate groundwater quality.

3. Survey locations of newly installed wells.

4.1 SUMMARY OF PROPOSED ACTIVITIES

Specific tasks to be conducted may include, but not be limited to, the following:

- Mobilization/Demobilization activities
- Drilling/Monitoring Well Installation
- Monitoring Well Development
- Subsurface Soil Sampling
- Groundwater Sampling
- Decontamination of Sampling and Heavy Equipment
- Land Survey

5.0 TASKS/HAZARDS/ASSOCIATED CONTROL MEASURES SUMMARIZATION

Table 5-1 of this section serves as the primary portion of the site specific HASP and discusses the contaminants and physical hazards that are associated with each of the proposed tasks that are to be performed at the site. A new Table 5-1 must be developed and incorporated into this document should additional tasks occur at the site. Table 5-1 details the anticipated hazards, recommended control measures, air monitoring recommendations, required Personal Protective Equipment (PPE), and decontamination measures for each site task. This table and the associated control measures will be changed if the scope of work, contaminants of concern, or other conditions change.

By using the table, site personnel can determine the hazards associated with each task, the hazards present at each site, and the associated control measures necessary to minimize potential exposure or injuries related to those hazards. The table also assists field team members in determining which PPE and decontamination procedures to use, based on proper air monitoring techniques and site-specific conditions.

As discussed earlier, this table and HASP are accompanied by a Health and Safety Guidance Manual. This manual is designed to further explain supporting elements for any site specific operations as required by 29 CFR 1910.120. This Guidance Manual will be available at the site and should be referenced, as necessary, for additional information regarding air monitoring instrumentation, decontamination activities, emergency response, hazard assessments, hazard communication and hearing conservation programs, medical surveillance, PPE, respiratory protection, site control measures, standard work practices, and training requirements. Many of TtNUS's SOPs are also provided in this Guidance Manual.

TABLE 5-1
TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM
HEALTH AND SAFETY PLAN
FORMER MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND

Tasks/Operations/ Locations	Anticipated Hazards	Recommended Control Measures	Air Monitoring	Personal Protective Equipment	Decontamination Procedures
Mobilization/ Demobilization, Land Survey Activities	***Chemical hazards:*** Exposure to potential site contaminants are not anticipated during this activity. However, chemicals brought on site in support of field activities are to be identified, logged, accompanied by an appropriate MSDS, properly stored, and evaluated for purposes of hazard communication. ***Physical hazards:*** Potential physical hazards associated with this task may include: 1) Strain/muscle pulls from heavy lifting 2) Pinch/compression points 3) Uneven or unstable terrain (slip, trip, and fall hazards) 4) Natural hazards (insect/animal bites and stings, poisonous plants) 5) Other physical hazards associated with ongoing operations (foot and vehicular traffic)	***Chemical Hazards:*** To eliminate potential chemical hazards associated with this task ensure the following: - A chemical inventory list is generated and MSDSs are available for all chemicals brought on-site (Complete Section 5.0 of the Health and Safety Guidance Manual). - Materials are stored in accordance with recommended practices and according to compatibility (See MSDS for storage and compatibility recommendations). ***Physical hazards:*** 1) Use machinery or multiple personnel for heavy lifts. - Use proper lifting techniques. 2) Use pinch bars or other equipment to keep hands from the point of operation. 3) Preview and prepare work locations where unstable/uneven terrain exists. 4) Avoid insect/animal nesting areas, use repellents (Do NOT use repellents during sampling activities). Report potential hazards to the SSO. Frequently inspect clothing and persons during and after activities in wooded areas for ticks and other vectors. 5) Identify all access/egress routes and locations to within established areas of operation. - All equipment capable of self propelled movement will be equipped with movement alarms as applicable. - Traffic regulations for Tetra Tech NUS, Inc. and operational areas will be posted by the SSO as required.	Not required during mobilization/demobilization or land survey activities. Air monitoring will not be performed during these tasks due to the nature of the site contaminants and non-intrusive activities planned.	Mobilization/demobilization activities is intended to initiate and proceed in Level D protection. Level D - (Minimum Requirements) - Standard field attire (Work shirt; long pants; or coveralls) - Safety Boots with steel toe/shank - Safety glasses - Hardhat (when overhead hazards exists, or identified as an operation requirement) - Reflective vest for high traffic areas - Hearing protection for high noise areas, or as directed on an operation by operation scenario. As a general rule of thumb, if you need to raise your voice to be heard while engaged in conversation with someone who is within 2 feet of your position, you may be exposed to excessive noise levels. If this occurs, use hearing protection until the SSO can quantify the potential hazard through sound level measurements or noise dosimetry. **Note:** Additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	As potential site contaminants are not anticipated as part of this task, personal decontamination is not required. All equipment arriving/leaving the site will be inspected prior to permitting this equipment to enter or exit the site. The SSO will inspect the equipment and give the clearance to allow the equipment to pass. Failure to pass inspection will prohibit entering or exiting the site as applicable. All equipment which fails the inspection will have to be decontaminated again to a level acceptable to the SSO prior to passage on or off site.

TABLE 5-1 (cont.)
TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM
HEALTH AND SAFETY PLAN
FORMER MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND
PAGE 2 OF 4

Tasks/ Operation Location	Anticipated Hazards	Recommended Control Measures	Air Monitoring	Personal Protective Equipment	Decontamination Procedures
Drilling/Soil Borings/ Monitoring Well Installations	***Chemical hazards*** 1) PAHs associated with oil and oil-contaminated soils (Formerly present, removed 2000) 2) Transfer of contamination into clean areas or onto persons ***Physical hazards:*** Potential physical hazards associated with this task may include: 1) Strain/muscle pulls from heavy lifting 2) Pinch/compression points 3) Uneven or unstable terrain (slip, trip, and fall hazards) 4) Contact/entanglement with rotating equipment or machinery 5) Natural hazards (insect/animal bites and stings, poisonous plants) 6) Other physical hazards associated with ongoing operations (foot and vehicular traffic) 7) Noise in excess of 85dBA	***Chemical hazards*** 1) Use of identified PPE to control exposures to fuel oil contaminated medias - Identify operational zones where potential contamination may exist to prevent incidental contact and transfer outside of the operational area. 2) Decontaminate all equipment and supplies between drilling events as well as prior to leaving the site. ***Physical hazards*** 3) All equipment used will be: - Inspected in accordance with Federal safety and transportation guidelines, OSHA (1926.600,.601,.602), and manufacturer's design and documented as such. - Operated by Certified operators and knowledgeable ground crew. - Only manufacturer approved equipment may be used in conjunction with equipment repair procedures (e.g., pins for auger flights). In addition to the equipment considerations, the following standard operating procedures will be used: - All personnel not directly supporting the drilling operation will remain at least 25 feet from the point of operation. - All loose clothing/protective equipment will be secured to avoid possible entanglement. - Hand signals will be established prior to the commencement of drilling activities - Test and ensure that all personnel in proximity to the drill rig can locate and operate the emergency stop device. - The driller and helper can simultaneously handle moving augers or flights only when there is a standby person to activate the emergency stop device. - The driller must never leave the controls while tools are rotating unless all personnel are clear of the rotating equipment - A long handled shovel or equivalent shall be used to clear away drill cuttings from the hole and rotating equipment. Hands or feet shall not be used for this purpose - A remote sampling device must be used to sample drill cuttings near rotating tools. - Never climb a drill mast while equipment is rotating. - Work areas will be kept clear of clutter. - All personnel will be instructed in the location and operations of the emergency shut off device(s). This device will be tested initially (and then periodically) to ensure its operational status - Areas will be inspected prior to the movement of drill rigs and support vehicles to eliminate any physical hazards. This will be the responsibility of the FOL and/or SSO. - Drill rigs and support vehicles will be moved no closer to banks, ditches, and other excavations than 3 feet unless the wall is supported. 4) Excessive noise levels will be mitigated through the use of hearing protection. Any piece of equipment or operation that has the potential to generate excessive noise levels (i.e., you must raise your voice to speak to someone within two feet of where you are standing) will require hearing protection until sound level measurements and/or noise dosimetry may be conducted to quantify the associated noise levels. 5) All utility clearances shall be obtained through DIGSAFE prior to subsurface activities. The locations of all underground utilities will be identified and marked prior to all subsurface investigations. - Drill masts, backhoe booms or other projecting devices shall be at least 20 feet from overhead power lines and a minimum of 3 feet from identified underground locations. 6) Use machinery or multiple personnel for heavy lifts. - Use proper lifting techniques. 7) Preview work location for uneven/unstable terrain. 8) Use pinch bars or other equipment to remove hands from the point of operation, when acquiring samples. 9) Traffic and equipment considerations are to include the following: - Establish safe zones of approach (i.e. Boom + 3 feet). - All equipment shall be equipped with movement warning systems. - All personnel working in high equipment traffic areas are required to wear reflective vests for high visibility. - Use safety belts and follow the site traffic rules. Traffic patterns will be dictated supporting on-site activities. However, regulated patterns in and about the work zones and support thereof will be established to safely control the flow patterns of mechanized vehicles and pedestrians. 10) Wear appropriate clothing and PPE. Avoid potential nesting areas and suspicious vegetation (poison ivy, poison oak, etc.). When feasible and necessary, use commercially available insect repellents. Refer to the Health and Safety Guidance Manual for additional information regarding ticks and Lyme's disease. 11) Wear appropriate clothing for the anticipated weather conditions while maintaining the required level of protection. If necessary, perform biological monitoring.	No volatile contaminants are anticipated at the site, due to the removal action undertaken in 1997-2000, during which fill and all soil above the water table was removed from the site and replaced with clean fill. Therefore no air monitoring will be required during this post removal action monitoring	Activities are to be initiated in Level D protection. Level D protection constitutes the following minimum protection: - Standard field dress (Long pants and long or short sleeve shirts) - Steel toe/shank work boots These following items will be incorporated during drilling operations: - *Nitrile gloves* - Hardhat, safety glasses, and earplugs or muffs. - *Tyvek coveralls* - *Impermeable boot covers* - *PVC or PE coated Tyvek will be incorporated if there is a potential for saturation of work attire.* *(The italicized items are optional as conditions dictate)*	**Personnel Dec ntamination** - Will consist of a soap/water wash and rinse for outer protective equipment (e.g , boots, gloves, PVC splash suits, etc). This decontamination procedure for Level D protection will consist of - Equipment drop - Soap/water wash and rinse of outer gloves and outer boots, as applicable - Soap/water wash and rinse of the outer splash suit, as applicable - Wash hands and face, leave contamination reduction zone **Equipm nt Decontaminati n** - All equipment decontamination will take place at a centralized decontamination pad utilizing steam or pressure washers The FOL or the SSO will be responsible for evaluating equipment arriving on site and that which is to leave the site. No equipment will be allowed access or exit without this authorization.

TABLE 5-1 (cont.)
TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM
HEALTH AND SAFETY PLAN
FORMER MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND
PAGE 3 OF 4

Task/Operation/ Location	Anticipated Hazards	Recommended Control Measures	Air Monitoring	Personal Protective Equipment	Decontamination Procedures
Multi-media sampling including soils (surface and subsurface); groundwater; and Investigative Derived Waste (IDW). Activities such as water-level measurements, and well development are also involved in this task.	***Chemical hazards:*** 1) Residual oil and PAHs 2) Transfer of contamination into clean areas or onto persons. ***Physical hazards:*** 3) Strain/muscle pulls from heavy lifting 4) Pinch/compression points 5) Uneven or unstable terrain (slip, trip, and fall hazards) 6) Natural hazards (insect/animal bites and stings, poisonous plants, etc.) 7) Ambient temperature extremes	***Chemical hazards:*** 1) Use of PPE to control exposures to potentially contaminated medias (e.g. water and soils). 2) Restrict the cross use of equipment and supplies between sampling locations without first going through a suitable decontamination. ***Physical hazards:*** 3,4) Use machinery or multiple personnel for heavy lifts. Use proper lifting techniques. 5) Preview work locations for unstable/uneven terrain. 6) Avoid insect/animal nesting areas (Do NOT use insect repellents during sampling activities). Report potential hazards to the SSO. 7) Wear appropriate clothing for the anticipated weather conditions while maintaining the required level of protection. If necessary, perform biological monitoring.	No volatile contaminants are anticipated at the site, due to the removal action undertaken in 1997-2000, during which fill and all soil above the water table was removed from the site and replaced with clean fill. Therefore no air monitoring will be required during this post removal action monitoring. **If conditions do not present as anticipated, then site operations should be terminated and the HSO should be contacted.**	All sampling activities are anticipated to proceed in a Level D protection. Level D respiratory protection and the following minimum personal protective equipment: - Standard field dress (Long pants and long or short sleeve shirts) - Steel toe/shank work boots - disposable latex/nitrile glove when sampling - Safety glasses - *Tyvek coveralls will be worn if there is a possibility of soiling work attire* - *Impermeable boot covers* - *PVC or PE coated Tyvek will be incorporated if there is a potential for saturation of work attire.* *(The italicized items are optional as conditions dictate)*	**Personnel Decontamination** - Will consist of a soap/water wash and rinse for outer protective equipment (e.g., boots, gloves, tyvek coveralls, etc.). This decontamination procedure for Level D protection will consist of - Equipment drop - Soap/water wash and rinse of outer gloves and outer boots, as applicable - Soap/water wash and rinse of the outer splash suit, as applicable - Wash hands and face, leave contamination reduction zone **Equipment decontamination:** All sampling equipment will undergo a soap/water wash and rinse utilizing a suitable potable water source until visibly clean. Sampling equipment may also be high pressure soap/water wash and rinse or steam cleaned. All chemical decontamination will proceed in accordance with the other site documents such as the Work Plan.

TABLE 5-1 (cont.)
TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM
HEALTH AND SAFETY PLAN
FORMER MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND
PAGE 4 OF 4

Tasks/Operati n/ Locati ns	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring	Personal Protective Equipment*	Decontamination Procedures
Decontamination of sampling and heavy equipment	***Chemical hazards:*** 1) PAHs associated with oil and oil contaminated soils ***Physical hazards:*** 2) Strain/muscle pulls from heavy lifting 3) Pinch/compression points 4) Injuries associated with use of a high pressure steam cleaning device	1) Use protective equipment to minimize contact with site contaminants and hazardous decontamination fluids - Have a means by which the eyes and/or skin may be flushed (i.e., emergency eyewash, etc.) readily accessible. - Refer to MSDS for specific decontamination solvents and to determine appropriate PPE and safe handling procedures. 2) Use multiple persons where necessary for lifting and handling heavy pieces of equipment for decontamination purposes. 3) If necessary, provide stacking racks for air drying of decontaminated equipment to prevent unstable drying stacks of equipment from collapsing. 4) Use required PPE and operate the device in accordance with manufacturers recommendations.	1) Use visual observation on all equipment and/or areas which have been cleaned and dried to ensure they have been properly cleaned of potentially contaminated medias (e.g., air, water, soils).	***For Drill Rigs, etc.:*** This applies to high pressure soap/water, steam cleaning wash and rinse procedures. Level D Minimum requirements - - Standard field attire (Long and short sleeve shirt; long pants) - Work Boots (Steel toe/shank) - Chemical resistant boot covers - Nitrile outer gloves - PVC Rain suits or PE or PVC coated Tyvek - Safety glasses/splash shield ***For sampling equipment including trowels, split spoons, bailers, etc.:*** Level D Minimum requirements - - Standard field attire (Long and short sleeve shirt; long pants) - Work Boots (Steel toe/shank) - Nitrile gloves - Safety glasses In the event of overspray of chemical decontamination fluids, use PVC Rain suits or PE or PVC coated Tyvek as necessary. Respiratory protection is not anticipated for these activities.	This decontamination procedure for **Level D** protection will consist of - Soap/water wash and rinse of outer gloves - Soap/water wash and rinse of the outer splash suit, as applicable - Wash hands and face and leave contamination reduction zone

6.0 HAZARD ASSESSMENT

The following section provides information regarding the chemical and physical hazards associated with the former Melville North Landfill site and the activities that are to be conducted as part of the scope of work. Table 6-1 provides information on the most common and significant substances likely to be present at the site, based on review of available data. Specifically, toxicological information, exposure limits, symptoms of exposure, physical properties, and air monitoring and sampling data are discussed in the table. Section 6.1 discusses the contaminants that may be present at the site. Section 6.2 lists the physical hazards that may be present at the site or associated with site activities.

6.1 CHEMICAL HAZARDS

Fuel oil contamination was historically documented in the soils onsite. Contaminated soils have been excavated and transported offsite during several removal actions conducted in 1993, 1996, and 2000. Based on the current site conditions, a potential for a chemical exposure is not anticipated.

6.2 PHYSICAL HAZARDS

The physical hazards that may be present during the performance of site activities are summarized below.

- Contact/entanglement with rotating equipment or machinery.
- Uneven or unstable terrain (slip, trip, and fall hazards).
- Contact with underground or overhead utilities (electric lines, gas lines, water lines, etc.).
- Strain/muscle pulls from heavy lifting associated with drilling activities.
- Pinch/compression points.
- Noise in excess of 85 decibels (dBA).
- Inclement weather.

TABLE 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
HEALTH AND SAFETY PLAN
FORMER MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
General PAHs / Coal Tar Pitch Volatiles / Creosote / cresol (Fluoranthene, pyrene, benzo(a) anthracene, benzo(a) pyrene, benzo(f) fluoranthene, benzo(k)fluoranthene, etc)	(CAS Numbers vary depending on specific compound)	PID I P of 8 97 eV, relative response ratio unknown FID Response factor unknown but given the substances flammability, detection by FID can be anticipated	Refer to NIOSH methods for each specific compound for appropriate air sampling protocols Many PAHs can be sampled using NIOSH Method 5506 or 5515 - Teflon filter with support ring - High pressure liquid chromatography with UV detector For cresol (a major constituent of creosote) by silica gel or xad-7 sorbent tube, Acetone desorption and analysis by gas chromatography - flame ionization detector or high-pressure liquid chromatography (NIOSH Method #2001, or OSHA Method #32)	**General PAHs** Most PAHs have no established exposure limits Other Coal Tar Pitch Volatiles / PAHs such as chrysene and benzo(a)pyrene have an exposure limit of 0 2 mg/m^3 (OSHA and ACGIH) 0 1 mg/m^3 - (NIOSH) **Creosote / Cresol:** OSHA, ACGIH 5 ppm NIOSH 2 3 ppm IDLH. 80 mg/m3	Adequate - use a full-face air-purifying respirator with organic vapor / dust/mist cartridge up to 250 ppm Cresol has an Odor Threshold of 0 00005-0 0079 ppm **Recommended gloves:** Viton >96 00 hrs, butyl rubber >90 00 hrs, neoprene >4.50 hrs	Properties of various PAHs/Coal Tar Pitch Volatiles vary depending upon the specific compound. *For Creosote/Cresol* **Boiling Pt:** 376-397°F, 191-203°C **Melting Pt:** 52-96°F, 10 9-35 5°C **Solubility:** Insoluble **Flash Pt:** 178°F, 81°C **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** 3 72 **Vapor Pressure:** 1 mmHg @ 100-127°F, 38-53°C **Specific Gravity:** 1 030-1 038 **Incompatibilities:** Nitric acid, oleum, chlorosulfonic acid, oxidizers **Appearance and Odor:** Yellowish or colorless, flammable, oily liquid (often brownish because of impurities or oxidation)	Regulated based on effects on respiratory tract and skin irritation Other effects may include eye irritation and central nervous system, disturbances Acute exposures may result in difficulty breathing, respiratory failure and skin and eye irritation and burns Chronic exposure may damage the liver, kidneys, lungs and skin and cause photosensitivity IARC, NTP, NIOSH, ACGIH, and the EPA list some PAHs such as benzo(a)pyrene as a potential carcinogen (ARC 2A, NTP-2, ACGIH LTV-A2, NIOSH-X, EPA-B2)

- Ambient temperature extremes (heat or cold stress).
- Natural hazards (insect/animal bites or stings, poisonous plants)
- Other physical hazards associated with ongoing operations (proximity to heavy equipment and machinery, vehicular traffic, etc.).

These physical hazards are discussed in Table 5-1 as applicable to each site task. Furthermore, many of these hazards are discussed in detail in Section 4.0 of the Health and Safety Guidance Manual. Specific discussion on some of these hazards is presented below.

6.2.1 Contact with Underground or Overhead Utilities

Clearance of underground and overhead utilities must be coordinated through DIGSAFE. All project staff should be aware that areas where wells are planned to be installed were excavated to a depth of between 8 and 10 feet below ground surface in 2000. There are no overhead utilities in proposed well locations.

6.2.2 Ambient Temperature Extremes

Ambient temperature extremes (heat or cold stress) may exist during performance of this work depending on the project schedule. Work performed when temperatures are below 50°F may result in varying levels of cold stress (frost nip, frost bite, etc) depending on environmental factors such as temperature, wind speed, and humidity; psychological factors such as metabolic rate and moisture content of the skin, and other factors such as the protective clothing being worn Work performed when ambient temperatures exceed 70 °F may result in varying levels of heat stress (heat rash, heat cramps, heat exhaustion, and/or heat stroke) depending on factors similar to those presented for cold stress.

For more information concerning the effect and controls for cold and heat stress, see Section 4.0 of the Health and Safety Guidance Manual.

6.2.3 Natural Hazards

Given that proposed work will be conducted outdoors and in brush, marsh, and other natural areas, various animals, insects, or poisonous plants indigenous to the area may be encountered. During warm months (spring through early fall), tick-borne Lyme Disease may be a potential health hazard in the region. Specific information on Lyme Disease is included in Section 4.0 of the Health and Safety Guidance Manual In general, avoidance of areas of known insect infestation or poisonous plant growth

will be the preferred exposure control. In addition, individuals with known allergic reactions to insect bites and poisonous plants should notify SSO prior to engaging in activities where these hazards may be encountered.

7.0 AIR MONITORING

Based on the expected contaminants listed in Table 6-1 and the behavior of these contaminants in the environment, airborne exposures are not anticipated for the work to be performed. Therefore, air monitoring is not required for this project. However, air monitoring instruments will be maintained on site for screening of soil cuttings and samples collected (FID and PID). If conditions are encountered that would indicate volatile organic compounds may be present in the breathing zone (i.e. odors or heavily stained soils, sheens etc.), this HASP shall be modified to include ambient air and breathing zone monitoring.

8.0 TRAINING/MEDICAL SURVEILLANCE REQUIREMENTS

8.1 INTRODUCTORY/REFRESHER/SUPERVISORY TRAINING

This section is included to specify health and safety training and medical surveillance requirements for both TtNUS and subcontractor personnel participating in site activities

8.1.1 Requirements for TtNUS Personnel

All TtNUS personnel must complete 40 hours of introductory hazardous waste site training prior to performing work at the site. Additionally, TtNUS personnel who have had introductory training more than 12 months prior to site work must have completed 8 hours of refresher training within the past 12 months before they can be cleared for site work. In addition, 8-hour supervisory training in accordance with 29 CFR 1910.120(e)(4) will be required for site supervisory personnel.

Documentation of TtNUS introductory, supervisory and refresher training as well as site-specific training will be maintained at the TtNUS Wilmington office. Copies of certificates or other official documentation will be used to fulfill this requirement.

TtNUS will also conduct a brief meeting daily to discuss operations planned for that day. At the end of the workday, a short meeting will be held to discuss the operations completed and any problems encountered.

8.1.2 Requirements for Subcontractors

All TtNUS subcontractor personnel must have completed the 40-Hour introductory hazardous waste site training or equivalent work experience as defined in OSHA Standard 29 CFR 1910.120(e) and 8 hours of refresher training meeting the requirements of 29 CFR 1910.120(e)(8) prior to performing field work at the site. TtNUS subcontractors must certify that each employee has had such training by sending TtNUS a letter, on company letterhead, containing the information in the example letter shown in Figure 8-1 and by providing copies of certificates for all subcontractor personnel participating in site activities.

8.2 SITE-SPECIFIC TRAINING

TtNUS will provide site-specific training to all TtNUS employees and subcontractor personnel who will perform intrusive work on this project. Site-specific training will also be provided to all personnel (Navy, etc.) who may enter the site to perform functions that may be directly related to site operations. Site-specific training will include:

- Names of designated personnel and alternates responsible for site safety and health
- Safety, health, and other hazards present on site
- Use of personal protective equipment
- Work practices to minimize risks from hazards
- Safe use of engineering controls and equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- Contents of the Health and Safety Plan
- Emergency response procedures (evacuation and assembly points)
- Spill response procedures

Review of the contents of relevant Material Safety Data Sheets

Site-specific documentation will be verified through the use of Figure 8-2. All site personnel and visitors must sign this document upon receiving site-specific training.

8.3 MEDICAL SURVEILLANCE

8.3.1 Medical Surveillance Requirements for TtNUS Personnel

All TtNUS personnel participating in project field activities will have had a physical examination meeting the requirements of TtNUS's medical surveillance program and will be medically qualified to perform hazardous waste site work using respiratory protection.

Documentation for medical clearances will be maintained in the TtNUS Wilmington office and made available, as necessary.

FIGURE 8-1

TRAINING LETTER

The following statements must be typed on company letterhead and signed by an officer of the company and accompanied by copies of personnel training certificates:

LOGO
XYZ CORPORATION
555 E. 5th Street
Nowheresville, Kansas 55555

Month, day, year

Mr. Stephen Parker
Project Manager
TtNUS
55 Jonspin Road
Wilmington, MA 01887

Subject: HAZWOPER Training

Dear Mr. Parker:

As an officer of XYZ Corporation, I hereby state that I am aware of the potentially hazardous nature of the subject project. I also understand that it is our responsibility to comply with all applicable occupational safety and health regulations, including those stipulated in Title 29 of the Code of Federal Regulations (CFR), Parts 1900 through 1910 and Part 126.

I also understand that Title 29 CFR 1910.120, entitled "Hazardous Waste Operations and Emergency Response," requires an appropriate level of training for certain employees engaged in hazardous waste operations. In this regard, I hereby state that the following employees have had 40 hours of introductory hazardous waste site training or equivalent work experience as requested by 29 CFR 1910.120(e) and have had 8 hours of refresher training as applicable and as required by 29 CFR 1910.120(e)(8) I further state that site supervisory personnel have had training in accordance with 29 CFR 1910.120(e)(4).

LIST FULL NAMES OF EMPLOYEES AND THEIR SOCIAL SECURITY NUMBERS HERE.

Should you have any questions, please contact me at (555) 555-5555.

Sincerely,

(Name and Title of Company Officer)

FIGURE 8-2

SITE-SPECIFIC TRAINING DOCUMENTATION

My signature below indicates that I am aware of the potentially hazardous nature of performing site activities at the Former Melville North Landfill in Portsmouth, Rhode Island and that I have received site-specific training which included the elements presented below:

- Names of designated personnel and alternates responsible for site safety and health
- Safety, health, and other hazards present on-site
- Use of personal protective equipment
- Work practices to minimize risks from hazards
- Safe use of engineering controls and equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- Contents of the Health and Safety Plan
- Emergency response procedures (evacuation and assembly points)
- Spill response procedures
- Review of contents of relevant Material Safety Data Sheets

I further state that I have been given the opportunity to ask questions and that all of my questions have been answered to my satisfaction.

Name (Print Clearly)	Signature	Date

8.3.2 Medical Surveillance Requirements for Subcontractors

Subcontractors are required to obtain a certificate of their ability to perform hazardous waste site work and to wear respiratory protection. The "Subcontractor Medical Approval Form" provided in Figure 8-3 shall be used to satisfy this requirement, provided it is properly completed and signed by a licensed physician.

Subcontractors who have a company medical surveillance program meeting the requirements of paragraph (f) of OSHA 29 CFR 1910 120 can substitute the "Subcontractor Medical Approval Form" with a letter, on company letterhead, containing all of the information in the example letter presented in Figure 8-4 of this HASP.

8.3.3 Requirements for All Field Personnel

Each field team member entering the exclusion zone(s) shall be required to complete and submit a copy of the Medical Data Sheet presented in Section 7 of the Health and Safety Guidance Manual. This shall be provided to the SSO, prior to participating in site activities. The purpose of this document is to provide site personnel and emergency responders with additional information that may be necessary in order to administer medical attention.

8.4 SUBCONTRACTOR EXCEPTIONS

Subcontractors who will not enter the contamination reduction and exclusion zone during operation and whose activities involve no potential for exposure to site contaminants will not be required to meet the requirements for training/medical surveillance other than site-specific training as stipulated in Section 8.2

FIGURE 8-3
SUBCONTRACTOR MEDICAL APPROVAL FORM

For employees of _____
Company Name
Participant Name: _____ Date of Exam: _____

Part A

The above-named individual has:

1. Undergone a physical examination in accordance with OSHA Standard 29 CFR 1910.120, paragraph (f), and was found to be medically -

   ( ) qualified to perform work at the site

   ( ) not qualified to perform work at the site

and,

2. Undergone a physical examination in accordance with OSHA 29 CFR 1910.134(b)(10) and was found to be medically -

   ( ) qualified to wear respiratory protection

   ( ) not qualified to wear respiratory protection

My evaluation has been based on the following information, as provided to me by the employer.

( ) A copy of OSHA Standard 29 CFR 1910.120 and appendices.

( ) A description of the employee's duties as they relate to the employee's exposures.

( ) A list of known/suspected contaminants and their concentrations (if known)

( ) A description of any personal protective equipment used or to be used.

( ) Information from previous medical examinations of the employee that is not readily available to the examining physician.

Part B

I, _____, have examined _____
Physician's Name (print) Participant's Name (print)

and have determined the following information:

FIGURE 8-3
SUBCONTRACTOR MEDICAL APPROVAL FORM
PAGE TWO

1. Results of the medical examination and tests (excluding finding or diagnoses unrelated to occupational exposure):

   _____
   _____
   _____

2. Any detected medical conditions which would place the employee at increased risk of material impairment of the employee's health:

   _____
   _____
   _____

3 Recommended limitations upon the employee's assigned work:

   _____
   _____
   _____

I have informed this participant of the results of this medical examination and any medical conditions which require further examination of treatment.

Based on the information provided to me, and in view of the activities and hazard potentials involved at the site, this participant

( ) may
( ) may not

perform his/her assigned task.

Physician's Signature _____

Address _____

Phone Number _____

NOTE. Copies of test results are maintained and available at:

_____
Address

FIGURE 8-4

MEDICAL SURVEILLANCE LETTER

The following statements must be typed on company letterhead and signed by an officer of the company.

LOGO
XYZ CORPORATION
555 E. 5th Street
Nowheresville, Kansas 55555

Month, day, year

Mr. Stephen Parker
Project Manager
TtNUS
55 Jonspin Road
Wilmington, MA 01887

Subject: Medical Surveillance

Dear Mr. Parker.

As an officer of XYZ Corporation, I hereby state that the persons listed below have participated in a medical surveillance program meeting the requirements contained in paragraph (f) of Title 29 of the Code of Federal Regulations (CFR), Part 1910.120, entitled "Hazardous Waste Operations and Emergency Response: Final Rule." I further state that the persons listed below have had physical examinations under this program within the past 12 months and that they have been cleared, by a licensed physician, to perform hazardous waste site work and to wear positive- and negative-pressure respiratory protection. I also state that, to my knowledge, no person listed below has any medical restriction that would preclude him/her from working at the site.

LIST FULL NAMES OF EMPLOYEES AND THEIR SOCIAL SECURITY NUMBERS HERE.

Should you have any questions, please contact me at (555) 555-5555.

Sincerely,

(Name and Title of Company Officer)

9.0 SPILL CONTAINMENT PROGRAM

9.1 SCOPE AND APPLICATION

It is anticipated that quantities of bulk potentially hazardous materials (in amounts of approximately 55-gallons) will be handled during some of the site activities conducted as part of the scope of work. Significant quantities of waste water (decontamination, purge and development) and Investigative-Derived Wastes (IDW) may be generated as part of site activities It is not anticipated, however, that spillage of these materials would constitute a significant danger to human health or the environment. Furthermore, it is possible that as the job progresses, that disposable PPE and other non-reusable items may be generated. Temporary storage containers will be used to contain waste waters, IDW, and other unwanted items generated during investigation activities. These containers will be labeled with the site name, source, description of contents and the date the container was filled. If needed, samples will be collected and analyzed to characterize the material and determine appropriate disposal measures. Once characterized, the waste can be removed from the staging area and disposed of in accordance with Federal, State and local regulations.

9.2 POTENTIAL SPILL AREAS

Potential spill areas will be monitored in an ongoing attempt to prevent and control further potential contamination of the environment. Currently, there are various areas vulnerable to this hazard including the areas used for central staging and decontamination activities. Additionally, areas designated for handling, loading, and unloading of potentially contaminated soils, waters, and debris present limited potential for leaks or spills.

9.2.1 Site Drums/Containers

All drums/containers used for containing soils and liquids will be sealed, labeled, and staged within a centralized area awaiting shipment or disposal.

9.3 LEAK AND SPILL DETECTION

To establish an early detection of potential spills or leaks, a periodic walk around by the SSO will be conducted during working hours to visually determine that containers are not leaking. If a leak is detected, the first approach will be to transfer the container contents (using a hand pump) into a new container. Other provisions for the transfer of container contents will be made and the appropriate

emergency contacts will be notified, if necessary. In most instances, leaks will be collected and contained using absorbents such as Oil-dry, vermiculite, or sand, which will be stored at the staging area in a conspicuously marked drum. This material will also be containerized for disposal pending analyses All inspections will be documented in the Project Logbook.

9.4 PERSONNEL TRAINING AND SPILL PREVENTION

All personnel will be instructed on the procedures for spill prevention, containment and collection of hazardous materials in the site-specific training. The FOL and/or the SSO will serve as the Spill Response Coordinator for this operation should the need arise.

9.5 SPILL PREVENTION AND CONTAINMENT EQUIPMENT

The following represents the minimum equipment which will be maintained at the staging area at all times for the purpose of supporting this Spill Prevention/Containment Program.

- Sand, clean fill, vermiculite, or other noncombustible absorbent (oil-dry);
- Drums (55-gallon U.S. DOT 17-E or 17-H)
- Portable storage tanks (if necessary)
- Shovels, rakes, and brooms
- Hand operated drum pump with hose
- Labels

9.6 SPILL CONTROL PLAN

This section describes the procedures the TtNUS field crew members will employ upon the detection of a spill or leak.

1) Notify the SSO or FOL immediately upon the detection of a leak or spill.

2) Employ personnel protective equipment stored at the staging area. Take immediate actions to stop the leak or spill by plugging or patching the drum or raising the leak to the highest point. Spread the absorbent material in the area of the spill covering completely.

3) Transfer the material to a new container, collect and containerize the absorbent material. Label the new container appropriately. Await analyses for treatment or disposal options.

4) Solid spills will be recontainerized with 2-inches of top cover and will await test results for treatment or disposal options.

It is not anticipated that a spill will occur in which the field crews cannot handle. Should this occur notification of appropriate emergency response agencies will be carried out by the FOL or SSO.

10.0 SITE CONTROL

This section outlines the means by which TtNUS will delineate work zones and use these work zones in conjunction with decontamination procedures in order to prevent the spread of contaminants into previously unaffected areas of the site. It is anticipated that a three-zone approach will be used during work at this site. This three zone approach will utilize an exclusion zone, a contamination reduction zone, and a support zone. It is also anticipated that this control measure will be used to control access to site work areas. Use of such controls will restrict the general public, minimize the potential for the spread of contaminants and protect individuals who are not cleared to enter work areas.

10.1 EXCLUSION ZONE

The exclusion zone will be considered the area of the site where drilling or groundwater sampling is performed. Access to within 25 feet of drilling operations should be restricted

10.1.1 Exclusion Zone Clearance

Prior to the initiation of site activities, utility locations will be identified by utility companies contacted through DIGSAFE. The positions of identified utilities will be field located and staked to minimize the potential for damage during intrusive activities. Sample locations can be located to avoid buried utilities. In the event that a utility is struck during a subsurface investigative activity, the emergency numbers provided in Table 2-1 will be notified.

Access to work areas will be controlled by TtNUS personnel. No personnel will be permitted to enter site exclusion zones without site-specific training.

10.2 CONTAMINATION REDUCTION ZONE

The contamination reduction zone (CRZ) will be a buffer area between the exclusion zone and any area of the site where contamination is not suspected. The personnel and/or equipment decontamination will take place in this area at a central location to facilitate and support field activities. When applicable, this area will be delineated using barrier tape, cones and/or drive poles, and postings to inform and direct facility personnel.

10.3 SUPPORT ZONE

The support zone for this project will include a staging area where a trailer and/or site vehicles will be parked, equipment will be unloaded, and where food and drink containers will be maintained. In all cases, the support zones will be established at areas of the site where exposure to site contaminants would not be expected during normal working conditions or foreseeable emergencies.

10.4 SITE VISITORS

Site visitors for the purpose of this document are identified as representing the following groups of individuals:

- Personnel invited to observe or participate in operations by TtNUS
- Regulatory personnel
- Other authorized visitors

All personnel working on this project are required to gain initial access to the site by coordinating with the TtNUS FOL or designee and following established site access procedures.

Once access to the site is obtained, all personnel who require site access into areas of ongoing operations will be required to obtain permission from the FOL and SSO. Upon gaining access to the site, all site visitors interested in observing operations in progress will be escorted by a TtNUS representative (arranged for by the FOL) and shall be required to meet the following minimum requirements:

- All site visitors will be routed to the FOL, who will sign them into the field logbook. Information to be recorded in the logbook will include the individual's name (proper identification required), the entity which they represent, and the purpose of the visit.

- All site visitors will be required to produce the necessary information supporting clearance to the site. This shall include information attesting to applicable training (40-hours of HAZWOPER training) and medical surveillance as stipulated in Section 8 0 of this document. In addition, to enter the site operational zones during planned activities, all visitors will be required to first go through site-specific training covering the topics stipulated in Section 8.2 of this HASP

Once the site visitors have completed the above items, they will be permitted to enter the operational zone. All visitors are required to observe the protective equipment and site restrictions in effect at the

site at the time of their visit. Any and all visitors not meeting the requirements stipulated in this plan will not be permitted to enter the site operational zones during planned activities. Any incidence of unauthorized site visitation will cause the termination of all on-site activities until the unauthorized visitor is removed from the premises. Removal of unauthorized visitors will be accomplished with support from the FOL or SSO.

10.5 SITE SECURITY

Site security will be the responsibilities of TtNUS and their subcontractor personnel as necessary. TtNUS will retain control over active operational areas. The first line of security consists of site safety cones or determined distances that restrict the general public. The second line of security will take place at the work site referring interested parties to the FOL. The FOL will serve as a focal point for site personnel, and will serve and the final line of security and the primary enforcement contact.

10.6 SITE MAP

Once the areas of contamination, access routes, utilities, topography, and evacuation routes are determined, a site map will be generated and adjusted as site conditions change. These maps will show utility locations, potential points of contact with the public, roadways, and other significant characteristics that may impact site operations and safety. A site map to the hospital will also be provided

10.7 BUDDY SYSTEM

Personnel engaged in on-site activities will practice the "buddy system" to ensure the safety of all personnel involved in this operation.

10.8 MATERIAL SAFETY DATA SHEET (MSDS) REQUIREMENTS

TtNUS and subcontractor personnel will provide MSDSs for all chemicals brought on-site. The contents of these documents will be reviewed by the SSO with the user(s) of the chemical substances prior to any actual use or application of the substances on site. A chemical inventory of all chemicals used on site will be developed using Figure 1 (Section 5) of the Health and Safety Guidance Manual. The MSDSs will then be maintained in a central location and will be available for anyone to review upon request.

10.9 COMMUNICATION

If personnel are not working in proximity to one another during field activities, a supported means of communication between field crews may be necessary. As a result, two-way radio communication devices may be used by field personnel while at the site.

External communication will be accomplished by using provided telephones (e.g. cellular phone) at the site.

11.0 CONFINED SPACE ENTRY

It is not anticipated, under the proposed scope of work, that permit-required confined space activities will be conducted. **Therefore, personnel under the provisions of this HASP are not allowed, under any circumstances, to enter confined spaces**. A confined space is defined as an area which has one or more of the following characteristics:

- Is large enough and so configured that an employee can bodily enter and perform assigned work.
- Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry).
- Is not designed for continuous employee occupancy.

A Permit-Required Confined Space is one that:

- Contains or has a potential to contain a hazardous atmosphere.
- Contains a material that has the potential to engulf an entrant.
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section.
- Contains any other recognized and serious safety or health hazard.

For further information on confined space, consult the Health and Safety Guidance Manual or call the SSO. If confined space operations are to be performed as part of the scope of work, detailed procedures and training requirements will have to be addressed.

12.0 MATERIALS AND DOCUMENTATION

The TtNUS FOL shall ensure the following materials/documents are taken to the project site and used when required.

- A complete copy of this HASP
- Health and Safety Guidance Manual
- Incident Reports
- Medical Data Sheets
- Material Safety Data Sheets for all chemicals brought on-site, including decon solutions, fuels, lime, sample preservatives, calibration gases, etc.
- Follow-up Reports
- A full-size OSHA Job Safety and Health Poster (posted in the site trailers)
- Training/Medical Surveillance Documentation Form (Blank)
- First-Aid Supply Usage Form
- Emergency Reference Form (TtNUS H & S Guidance Manual, Section 2.0, extra copy for posting)

12.1 MATERIALS TO BE POSTED AT THE SITE

The following documentation is to be posted at the site for quick reference purposes. In situations where posting of these documents is not feasible, these documents should be separated and immediately accessible.

Chemical Inventory Listing - This list represents all chemicals brought on site, including decontamination solutions, sample preservatives, fuel, calibration gases, etc. This list should be posted in a central area.

Material Safety Data Sheets (MSDSs) - The MSDSs should also be in a central area accessible to all site personnel. These documents should match all the listings on the chemical inventory list for all substances employed on site. It is acceptable to have these documents within a central folder and the chemical inventory as the table of contents.

The OSHA Job Safety & Health Protection Poster - This poster, as directed by 29 CFR 1903.2 (a)(1), should be conspicuously posted in places where notices to employees are normally posted. Each FOL shall ensure that this poster is not defaced, altered, or covered by other material.

Site Clearance Posting - This list is found within the training section of the HASP (See Figure 8-1). This list identifies all site personnel, dates of training (including site-specific training), and medical surveillance. This list indicates not only clearance but also status. If personnel do not meet these requirements, they do not enter the site while site personnel are engaged in activities.

Emergency Phone Numbers and Directions to the Hospital(s) - This list of numbers and the directions will be maintained at all phone communications points and in each site vehicle.

Medical Data Sheets/Cards - Medical Data Sheets will be filled out by all on-site personnel and filed in a central location. The Medical Data Sheet will accompany any injury or illness requiring medical attention to the medical facility. A copy of this sheet or a wallet card will be given to all personnel to be carried on their person.

Placards and Labels - Chemical inventories that have been separated, because of quantities and incompatibilities, will be conspicuously marked using Department of Transportation (DOT) placards and acceptable [Hazard Communication 29 CFR 1910 1200 (f)] labels.

TtNUS Health and Safety Guidance Manual – This document contains supporting information pertaining to procedures detailed in the HASP as well as TtNUS standard operating procedures.

Work Plan Addendum No. 9 – This document presents the scope of work and field activities planned onsite and addressed by this HASP.